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Plate I.

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A MANUAL

FOR THE

STUDY OF INSECTS

BY

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AND

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PREFACE.

FOR many years the most pressing demand of teachers and learners in entomology in this country has been for a handbook by means of which the names and relative affinities of insects may be determined in some such way as plants are classified by the aid of the well-known manuals of botany. But, as the science of entomology is still in its infancy, the preparation of such a handbook has been impossible. Excellent treatises on particular groups of insects have been published ; but no general work including analytical keys to all the orders and families has appeared. It is to meet this need that this work has been prepared.

The reader must not expect, however, to find that degree of completeness in this work which exists in the manuals of flowering plants. The number of species of insects is so great that a work including adequate descriptions of all those occurring in our fauna would rival in size one of the larger encyclopædias. It is obvious that such a work is not what is needed by the teachers and students in our schools, even if it were possible to prepare it. An elementary work on systematic entomology will always of necessity be restricted to a discussion of the characteristics of the orders and families, and descriptions of a few species as illustrations. Complete synopses of species will be appropriate only in works treating of limited groups. It is believed, therefore, that it would not be wise to materially change the scope of

the present work even if it were possible to describe all of our species.

Although much pains has been taken to render easy the classification of specimens, an effort has been made to give the mere determination of the names of insects a very subordinate place. The groups of insects have been fully characterized, so that their relative affinities may be learned; and much space has been given to accounts of the habits and transformations of the forms described. As the needs of agricultural students have been kept constantly in view, those species that are of economic importance have been described as fully as practicable, and particular attention has been given to descriptions of the methods of destroying those that are noxious, or of preventing their ravages.

An effort has been made to simplify the study of insects as much as possible without sacrificing accuracy in the descriptions. Only such morphological terms have been used as were necessary to accomplish the object of the book in a satisfactory manner. And so far as possible a uniform nomenclature has been used for all orders of insects. The fact that writers on each order of insects have a peculiar nomenclature has been a serious obstacle to the progress of entomology; this is especially true as regards the nomenclature of the wing-veins. It has been necessary for the student in passing from the study of one order of insects to that of another to learn a new set of terms; and in many cases writers on a single family have a peculiar nomenclature.

The present writer has endeavored to remove this obstacle by making a serious study of the homologies of the wing-veins, and by applying the same term throughout the work to homologous veins. The result is that the student is required to learn only one set of terms; and in applying these terms there will be brought to his attention in a forcible manner the peculiar modifications of structure characteristic of each order of insects. Heretofore, with a different nomenclature for the wing-veins of each order such a

comparative study of the various methods of specialization has been beyond the reach of any but the most advanced scholars.

The principal features of the method of notation of wing-veins proposed by Josef Redtenbacher has been adopted. But as the writer's views regarding the structure of the wings of primitive insects are very different from those of Redtenbacher, the nomenclature proposed in this book is to a great extent original. The chief point of difference arises from the belief by the present writer that veins IV and VI do not exist in the Lepidoptera, Diptera, and Hymenoptera; and that, in those orders where they do exist, they are secondary developments. The reasons for this belief are set forth at length in my essay on Evolution and Taxonomy.

In this essay there was proposed a new classification of the Lepidoptera, which was the result of an effort to work out the phylogeny of the divisions of this order. This classification has been further elaborated in the present work. In the other orders but few changes have been made from the more generally accepted classifications. It is more than probable however, that when the taxonomic principles upon which this classification of the Lepidoptera is based are applied to the classification of the other orders radical changes will be found to be necessary.

A serious obstacle to the popularization of Natural History is the technical names that it is necessary to use. In order to reduce this difficulty to a minimum the pronunciation of all of the Latin terms used has been indicated, by dividing each into syllables and marking the accented syllable. In doing this the well-established rules for the division of Latin words into syllables have been followed. It seems necessary to state this fact in order to account for differences which exist between the pronunciations given here and some of those in certain large dictionaries recently published in this country.

Nearly all of the wood-cuts have been engraved from nature by the Junior Author. As the skill which she has attained in this art has been acquired during the progress of the work on this book, some of the earlier-made illustrations do not fairly represent her present standing as an engraver. But it does not seem worth while to delay the appearance of the book in order to re-engrave these figures; especially as it is believed that they will not be found lacking in scientific accuracy. The generous appreciation which the best engravers have shown towards the greater part of the work leads us to hope that it will be welcomed as an important addition to entomological illustrations.

Although the chief work of the Junior Author has been with the pencil and graver, many parts of the text are from her pen. But in justice to her it should be said that the plan of the book was changed after she had finished her writing. It was intended at first to make the book of a much more elementary nature than it is in its final form. It has seemed best, however, to leave these parts as written in order that the work may be of interest to a wider range of readers than it would be were it restricted to a uniform style of treatment.

The figures illustrating the venation of the wings of insects have been drawn with great care under the writer's direction by Mr. E. P. Felt and Mr. R. H. Pettit. About one half of those in the chapter on Lepidoptera were drawn by Mr. Felt; the others in this chapter and those in the chapters on Diptera and Hymenoptera were drawn by Mr. Pettit.

I wish also to acknowledge the help of my Assistant Mr. A. D. MacGillivray, to whom I am indebted for much aid in bibliographical researches and in many other ways; also, that of Dr. A. C. White of the Cornell University Library, who has generously given much time to determining the etymologies of many of the more obscure words the pronunciations of which are indicated in the text.

To the authorities of Cornell University the authors of this book are under deep obligation for aid and encouragement. The preparation of the work would not have been possible but for the liberal grants which they have made for the purchase of specimens and books.

JOHN HENRY COMSTOCK.

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CORNELL UNIVERSITY,
December, 1894.

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A MANUAL FOR
THE STUDY OF INSECTS.

CHAPTER I.

ZOOLOGICAL CLASSIFICATION AND NOMENCLATURE

I. Zoological Classification.

(*For advanced students.*)

In order that the myriad forms of animals may be studied with facility some system of classification is necessary. And now that we have learned that there exists a blood-relationship between the different kinds of animals, that system which most clearly expresses this relationship is doubtless the best. This system is termed the *Natural Classification*.

It is now generally believed that long ago, in early geological times, there existed on the earth only very simple animals and plants; and that from these simple beginnings more and more complex forms have been developed. This growth in complexity has taken place in different descendants of these simple primitive beings in very different ways. Thus while it is probable that the first animals lived in water, and very many still do so, others have become adapted to life on the land, and in still others organs have been developed by which they can fly through the air. And under each of these conditions we find a great diversity of forms, each fitted for some special mode of life.

The diversity of forms of animal life is much greater than is commonly supposed. A competent authority has estimated that there are now living on the earth more than one million species of animals. And these are merely the surviving descendants of immense series of beings that have existed in past geological times, the remaining tips of a great genealogical tree, of which many twigs and branches have perished.

The common figurative use of the word tree in this connection expresses well the convergence of the lines of descent toward the common ancestor from which existing forms have descended. But in one respect it may be misleading. If an ordinary tree be examined, the tip of one branch will closely resemble that of any other branch of the same tree. But in this figurative genealogical tree we must imagine a very different state of affairs. Here the law of growth is constant change; each branch grows in its own individual way; and each twig of each branch bears fruit peculiar to itself. The changes, however, are gradual; and thus the tips of closely-connected twigs will be similar though not identical; while the tips of two branches that separated early in the growth of the tree will be very different.

It is the effort of the systematist, one who studies the classification of animals and plants, to work out the relations which exist between the various tips of the genealogical tree. This study when carried to its fullest extent includes not only the study of existing forms of life, but also the study of those that have perished, the trunk-forms from which existing forms have descended. This, however, is a very difficult matter; and as yet only the beginnings of the Natural Classification have been made. See pp. 199 to 204.

If we accept this theory of descent, now almost universally accepted by naturalists, it is evident that when we take into account all the forms of life that have existed we cannot classify animals into well-marked groups; for as the modification in form is gradual, series of connecting links have existed between any two forms that might be selected.

But practically the student that confines his attention to the study of living forms can classify these forms into more or less well-marked groups, for many of the connecting links have perished; in fact, the groups of living animals and plants are so distinct that it is only in recent years that naturalists have come to understand the blood-relationship referred to above.

We find that the Animal and Vegetable Kingdoms are made up of a vast assemblage of individuals, each the offspring of parents similar

to itself, and each in turn producing similar offspring. Although the offspring is never exactly like either parent, the degree of variation in a single generation is slight. And thus we find that there exist large numbers of individuals which very closely resemble each other. Such collection of individuals is termed in popular language a *kind*, in scientific language a *species*. Thus the kind of pine trees known as pitch-pine is a species; and scrub-pine, still another. In the same way the name sparrow-hawk indicates a kind or species of hawk; and pigeon-hawk, another species.

Roughly speaking, a species is a collection of individuals which resemble each other as closely as the offspring of a single parent. For example, if any two pitch-pines be studied, nothing will be found to indicate that they may not have sprung from seeds grown upon the same tree. On the other hand, if a pitch-pine and a white-pine be carefully compared, they will be found so different that no competent observer would believe that they had a common parent.

Unfortunately this mode of defining the limits of a species cannot be depended upon. Many instances are known where forms of animals or plants living in widely-separated regions differ so greatly that they have been considered distinct species until more extended collections in the intermediate regions have brought to light series of intermediate forms, which connect the two so-called species so closely that it is impossible to say where the one ends and the other begins.

The only definite way of determining whether two forms are specifically distinct is to determine whether they naturally interbreed or not. We find among wild animals a sort of race prejudice which keeps the members of different species from pairing, although they may do so when demoralized by domestication. Except in the case of very-closely-allied species, the pairing of individuals of different species results in no offspring or in the production of sterile offspring.

This grouping of individuals into species not only facilitates our study of Natural History, but expresses certain important facts of inheritance and reproduction. A second and somewhat similar step is made by grouping species into genera.

We find that there exist groups of closely-allied species, species that resemble each other in all of the more important characters, and differ among themselves only in what are known as the specific characters. Such a group of species is termed a *genus*. Thus all the different species of pine taken together constitute the genus pine, or *Pinus*, as it is termed by botanists. There are many species of oak,

as red-oak, live-oak, and water-oak. All of the species of oak taken together constitute the genus *Quercus* of botanists. Several species of hawks and falcons are classed together by zoologists as the genus *Falco*.

The genera in turn are grouped into *families*. Thus the pines, the spruces, and the larches resemble each other quite closely, and are classed together as the Pine Family (*Abietineæ*); the falcons, hawks, kites, and eagles are classed together as the Falcon Family (*Falconidæ*).

Closely-allied families are grouped together to form *orders*. The Pine Family, the Cypress Family, and the Yew Family comprise the Order *Coniferæ*, or cone-bearing plants, of botanists. The Owl Family (*Strigidæ*), the Falcon Family (*Falconidæ*), and the Vulture Family (*Vulturidæ*) constitute the Order *Raptores*, or Birds of Prey.

Closely-allied orders are grouped together to form *classes*. Thus all the orders of birds taken together constitute the Class *Aves* or Birds.

The classes are grouped into *branches*, which are the principal divisions of the Animal Kingdom.* In studying the different forms of animals it is found that there are several distinct types of structure. Some animals are built upon one plan or structure, and others on other plans. All animals built on the same plan are said to belong to the same Branch. Thus the back-boned animals comprise the *Branch Vertebrata;* the clams, oysters, snails, cuttle-fish, and certain other allied forms comprise the *Branch Mollusca;* and the insects, spiders, centipedes, lobsters, and their near relatives comprise the *Branch Arthropoda*.

All the branches of animals taken together constitute the *Animal Kingdom*.

It is not possible to lay down rules by which these different groups of animals can be limited. For, as has been shown in our discussion of species, all have been connected in past time by intermediate forms. But notwithstanding this, each of the terms given above (Branch, Class, Order, Family, Genus, and Species) expresses a pretty definite conception, which the student will learn to comprehend by practice in classifying animals. But the sequence in rank of these groups should be learned at the outset. Beginning with the most comprehensive it is as follows:

---

* The principal divisions of the Vegetable Kingdom are not termed Branches; hence we will not make further use of botanical illustrations in this connection.

Animal Kingdom
Branch or Subkingdom.
Class.
Order.
Family.
Genus.
Species.
Individual.

It is sometime desirable to indicate other groups than those named above. Thus a family may be divided into subfamilies, or an order into suborders. And occasionally an even more minute division is made. Thus several closely-allied families may be grouped together as a superfamily, a group of lower rank than a suborder. The following table includes all the grades of groups now commonly employed:

Kingdom.
Branch or Subkingdom.
Class.
Subclass.
Superorder.
Order.
Suborder.
Superfamily.
Family.
Subfamily.
Genus.
Subgenus.
Species.
Subspecies.
Variety.
Individual.

II. Zoological Nomenclature.

(*For advanced students.*)

At the beginning of his studies of Natural History the student is met with what is to him a new and strange set of names. These names are often long. In form they belong to a dead language, with which, in these days, even many educated people are unfamiliar. It is not strange that we often hear complaint respecting the difficulty of this nomenclature.

A little study of the matter, however, is sufficient to show the necessity for scientific names. The common names of animals will not answer our purpose; for the same name is often applied to widely different animals in different localities, while a single species of animal is known by totally different names in different sections of the country.

In order that information respecting animals may be recorded so that there need not be any doubt regarding the animal to which reference is made, it is necessary that each species or group of species should have a distinct name by which it shall be known by naturalists in all parts of the world. Therefore, to each branch, class, order, family, genus, and species which has been described there has been given a special name, by which it is known, and which pertains to this group alone.

As this nomenclature is used by all naturalists of whatever nationality, it is necessary that the names should be in a language which can be understood by all. As Latin was the language in which most scientific books were written at the time this nomenclature was established, that language was chosen as the universal language of science; and the rule has been adopted that all names of animals and plants shall be Latin, or Latin in form.

The name of a species consists of two words—the name of the genus to which the species belongs, followed by an adjective indicating the particular species; for in Latin an adjective follows the noun which it qualifies, instead of preceding it as in English. Thus the scientific name of the Pigeon-hawk is *Falco columbarius;* that of the Sparrow-hawk is *Falco sparverius;* and that of the Prairie-falcon is *Falco mexicanus.*

In the case of many species we find well-marked subspecies or geographical races which it is desirable to distinguish by name. Thus the Pigeon-hawk occurs over the whole of North America. But we find that those that live in the northwest coast region extending from California to Sitka, constitute a distinct geographical race known as the Black Merlin. As the Black Merlin and the typical Pigeon-hawk intergrade, they constitute a single species, which is known as *Falco columbarius.* To the Black Merlin has been applied the subspecific name *suckleyi.* When, therefore, it is desired to refer to the Black Merlin as distinguished from the typical Pigeon-hawk the term *Falco columbarius suckleyi* is used. If reference is to be made to the typical Pigeon-hawk as distinguished from the Black Merlin, it is designated as *Falco columbarius columbarius.*

In writing long names like those given above they are frequently

abbreviated if the context is such that the abbreviations will be readily understood. Thus the name of the Black Merlin may be written *Falco c. suckleyi* or *F. c. suckleyi*.

Subspecific names are used by entomologists not only to distinguish geographical races, but also to distinguish the different forms of dimorphic and polymorphic species. A good illustration is afforded by a certain species of Swallow-tail Butterfly common in the Atlantic States. This species exists under two distinct forms; one of these is yellow marked with black, and has long been known as *Jasoniades turnus;* the other is almost entirely black, and has been known as *Jasoniades glaucus*. At first it was supposed that these were different species; but in recent years the two forms have been bred from eggs laid by the same female. It is thus evident that the two forms represent a single species. And as the form *glaucus* was first described its name is given to the species, which is now known as *Jasoniades glaucus*. This name *Jasoniades glaucus* is used when reference is made to the species as a whole. But if one wishes to refer to the black form alone, it is distinguished as *Jasoniades glaucus glaucus;* while the yellow form is distinguished as *Jasoniades glaucus turnus*.

In the illustrations just given the dimorphism occurs in the same generation. But many instances are known where the dimorphism is seasonal. Thus in the case of certain insects which pass through two or more generations in the course of a year, the different generations, or some of them, differ markedly in form or coloring from the others. These differences in many cases are so great that the different generations of the same species were believed to be distinct species till they were bred from each other. It is therefore often desirable to distinguish these different forms by subspecific names. Thus *Iphiclides ajax* is a species of Swallow-tail Butterfly which exists under three distinct seasonal forms: an early spring form, *I. ajax marcellus;* a late spring form, *I. ajax telamonides;* and a summer form, *I. ajax ajax*.

The name of a genus or of a subgenus is always a single word, and should be a noun in the singular number and nominative case.

The names of all groups of genera (i.e., families, orders, classes, and branches) consist each of a single word; and this word should be a plural noun in the nominative case.

The following practices regarding the forms of zoological names are now almost universally followed:

The names of all groups in zoology, from kingdom to subgenus inclusive, are written and printed with a capital initial letter.

Specific and subspecific names are written and printed with a small initial letter. Thus in writing the name of a species the generic name is capitalized, the specific name not; *e.g.*, *Iphiclides ajax*.

The names of families end in *idæ;* the names of subfamilies, in *inæ*.

It will aid the student greatly in the pronunciation of family and subfamily names to know that the *i* of *-idæ* in family names is short, and consequently the accent falls on the syllable preceding this letter; while the *i* of *-inæ* of subfamily names is long, and is consequently accented.* Numerous examples are given in the following pages.

---

* This in accordance with the rule of Latin grammar that in words of more than two syllables the penult if long is accented; but if the penult is short the accent falls on the antepenult.

CHAPTER II.

INSECTS AND THEIR NEAR RELATIVES.

Branch ARTHROPODA (Ar-throp'o-da).

The Arthropods (*Ar'thro-pods*).

If an insect, a spider, a scorpion, a centipede, or a lobster be examined, the body will be found to be composed of a series of more or less similar rings or segments joined together; and some of these segments will be found to bear jointed legs (Fig. 1). All the animals possessing these characteristics are classed together as the *Branch Arthropoda.*

FIG. 1.—An insect showing segmented form of body.

A similar segmented form of the body is found among worms; but these are distinguished from the Arthropods by the absence of legs. It should be remembered that many animals commonly called worms, as the tomato-worm, apple-worm, etc., are not true worms, but are the larvæ of insects (Fig. 2). The angle-worm is the most familiar example of a true worm.

The Branch Arthropoda is the largest of the branches of the Animal Kingdom, including many more known species than all the other branches taken together. Our common representatives are distributed among four classes: these are the Crustacea, the Arachnida, the Myriapoda, and the Hexapoda. The

first three classes are briefly discussed in this chapter; the fourth comprises the Insects, and is the subject of the remaining parts of this book.

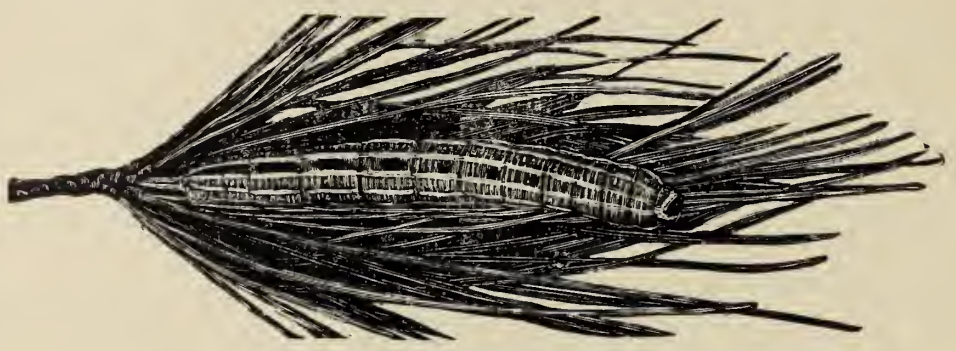

FIG. 2.—A larva of an insect.

The following table will enable the student to distinguish the classes of the Arthropoda.*

TABLE OF CLASSES OF THE ARTHROPODA.

A. With two pairs of antennæ and at least five pairs of legs. Aquatic animals breathing by gills. p. 11..... CRUSTACEA.

AA. With one pair of antennæ or with none. Air-breathing animals. The number of legs varies from six to many.

---

* The following is the method of using the analytical tables given in this book: Read carefully the statement of characteristics given opposite A and AA respectively, and by examining the animal to be classified determine which is true of this animal. This will indicate in which division of the table the name of the group to which the animal belongs is to be looked for. If this division of the table is subdivided, pass to B and BB (also to BBB if it occurs) *in this division* and determine in a like manner under which the animal belongs. Continue in this way, passing to the letters C, D, E, etc., in regular order till the name of the group is reached. Then turn to the page indicated and read the description or the group given there, comparing the specimens with the description. It should be borne in mind that an analytical table is merely an aid to the determination of groups. As the groups that we recognize are not always sharply limited in nature, we cannot expect to be able in every case to find characters that will serve to distinctly separate them in a table. Therefore when a student has determined by the aid of a key to what group a species seems to belong, he should verify this determination by a study of the characters of that group given in the detailed discussion of it.

B. Without antennæ and with four pairs of legs, although the maxillary palpi are often leg-like in form, making the animal appear to have five pairs of legs. p. 12.....ARACHNIDA.

BB. With antennæ.

C. With more than three pairs of legs; and without wings. p. 45.....MYRIAPODA.

CC. With only three pairs of legs, and usually with wings in the adult state. p.48.....HEXAPODA.

Class CRUSTACEA (Crus-ta'ce-a).

The Crustaceans (Crus-ta'ce-ans).

The members of this class are aquatic Arthropoda, which breathe by true gills. They have two pairs of antennæ and at least five pairs of legs.

The most familiar illustrations of the Crustacea are the Cray-fishes, the Lobsters, the Shrimps, and the Crabs. Cray-fishes (Fig. 3) abound in our brooks, and are often improperly called Crabs. The Lobsters, the Shrimps, and the true Crabs live in salt water.

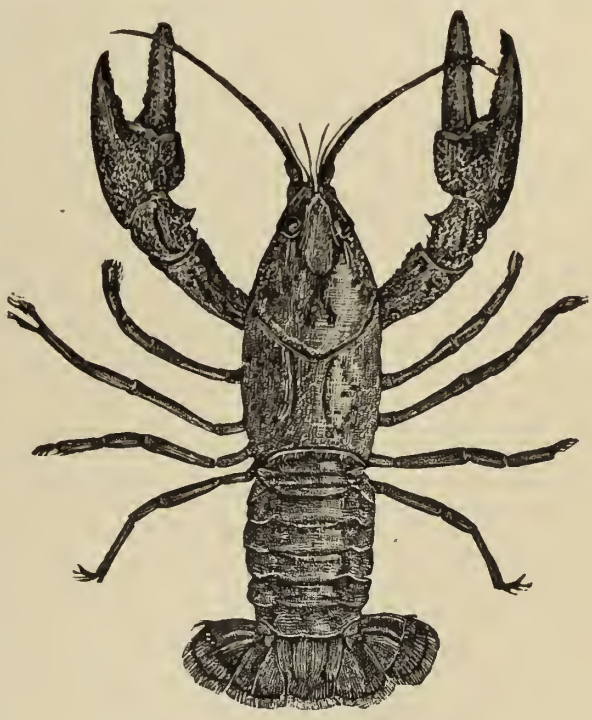

FIG. 3 —A Cray-fish.

The Crustaceans are distinguished from all other Arthropods by their mode of respiration, being the only ones that breathe by true gills. Many insects live in water, and are furnished with gill-like organs; but these are tracheal gills, organs which differ essentially in structure from true gills, as described later, in the chapter on Anatomy of Insects. The Crustacea also differ from other Arthropoda in having two pairs of antennæ; and from all

except the Myriapoda in having many (more than four) pairs of legs.

The illustrations named above are the more conspicuous members of the class; but many other smaller forms abound both in the sea and in fresh water. Some of the more minute fresh-water forms are almost sure to occur in any fresh-water aquarium. In Figure 4 are represented three of these, greatly enlarged.

FIG. 4.—Crustacea: *a*, *Cypris*; *b*, *Cyclops*; *c*, *Daphnia*.

Among the Crustacea that live in damp places on land the Sow-bugs, *Oniscidæ* (O-nis'ci-dæ), are most often seen. These frequently occur about water-soaked wood; and are often mistaken, by students beginning the study of Entomology, for insects or Myriapods. Figure 5 represents a Sow-bug.

FIG. 5.—A Sow-bug.

On the sea-coast an immense number of forms of Crustacea occur.

Class ARACHNIDA (A-rach'ni-da).

Scorpions, Harvestmen, Spiders, Mites, and others.

The members of this class are air-breathing Arthropods, in which the head and thorax are grown together, forming a cephalothorax, which have four pairs of legs fitted for walking, and which have no antennæ.

The Arachnida abound wherever insects occur, and are often mistaken for insects. But they can be easily distinguished by the characters given above, even in those cases where an exception occurs to some one of them. The more important of the exceptions are the following: In the Solpugida the head is distinct from the thorax; as a rule the young of mites have only six legs, but a fourth pair are added during growth; and in the gall mites (*Phytoptus*) there are only four legs.

In the Arachnida we find only simple eyes.

The *cephalothorax* (ceph-a-lo-tho'rax) bears six pairs of

appendages—two pairs of jaws, and four pairs of legs. The first pair of jaws are the *mandibles* (man'di-bles), the second, the *maxillæ* (max-il'læ).

The *mandibles* (Fig. 6, *md*) lie in front of and above the mouth, and consist each of two or three segments. They serve for seizing prey, and often also for killing it. In many books they are termed the *cheliceræ* (che-lic'e-ræ).

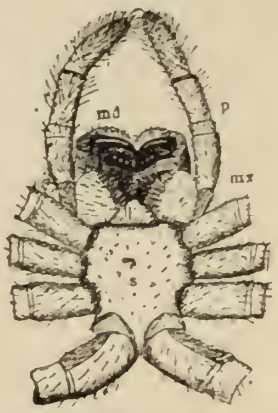

FIG. 6.—Lower side of cephalothorax of a spider: *md*, mandible; *mx*, maxilla; *p*, palpus; *l*, lower lip; *s*, sternum.

The *maxillæ* (Fig. 6, *mx*) lie just behind the mandibles, one on each side of the mouth. Each maxilla bears a large feeler or palpus (Fig. 6, *p*). These palpi vary greatly in form; frequently they resemble legs; hence many Arachnida appear to have five pairs of legs. The palpi are often so largely developed that each maxilla appears to be merely the first segment of its leg-like palpus. These appendages are often called the *pedipalpi* (ped-i-pal'pi). But as the name Pedipalpi is applied to one of the orders of the Arachnida, we will call these appendages the *palpi*.

FIG. 7.—Leg of a spider.

The legs of Arachnida consist typically of seven parts (Fig. 7), which are named, beginning with the one next to the body, as follows: 1, *coxa* (cox'a); 2, *trochanter* (tro-chan'ter); 3, *femur* (fe'mur); 4, *patella* (pa-tel'la); 5, *tibia* (tib'i-a); 6, *metatarsus* (met-a-tar'sus); and 7, *tarsus* (tar'sus). The tarsus may be composed of several segments, and is usually furnished with claws.

Two forms of breathing organs are found in this class: one, tracheæ, resembling the tracheæ of insects, described in the chapter on the anatomy of insects; and the other, tracheal lungs or lung sacs, which consist of many leaf-like plates enclosed in a sac. Both forms open by paired spiracles, which are usually situated on the lower side of some of the abdominal segments.

Very great differences exist in the several orders of the Arachnida in respect to the division of the body into segments. In arranging the orders in a series, we place first those in which the segments of the body are most distinctly indicated, while those which seem to depart more widely from the segmented type characteristic of the Arthropoda are placed later.

The class Arachnida includes seven orders; these are designated as follows:

The Scorpions, Order SCORPIONIDA (p. 15).
The Jointed Spiders, Order SOLPUGIDA (p. 16).
The Pseudoscorpions, Order PSEUDOSCORPIONES (p. 17).
The Whip-scorpions, Order PEDIPALPI (p. 17).
The Harvestmen, Order PHALANGIDEA (p. 19).
The Spiders, Order ARANEIDA (p. 20).
The Mites, Order ACARINA (p. 42).

TABLE OF THE ORDERS OF THE ARACHNIDA.

A. Abdomen distinctly segmented.
  B. Abdomen with a tail-like prolongation.
    C. Tail stout and armed with a sting at the end; first pair of legs not greatly elongated; a pair of comb-like appendages on the lower side of the second abdominal segment in the adult. (*Scorpions.*) p. 15.....SCORPIONIDA.
    CC. Tail slender, whip-lash-like, without sting; first pair of legs much longer than the others; without comb-like appendages on abdomen. (*Whip-scorpions.*) (*Thelyphonidæ.*) p. 17. PEDIPALPI.
  BB. Abdomen without a tail-like prolongation.
    C. Palpi with pincer-like claws. (*Pseudoscorpions.*) p. 17. PSEUDOSCORPIONES.
    CC. Palpi without pincer-like claws.
      D. Abdomen joined to the thorax by a slender stalk; front legs greatly elongated and with whip-lash-like tarsi. (*Whip-scorpions.*) (*Phrynidæ.*) p. 17.....PEDIPALPI.
      DD. Abdomen broadly joined to the thorax.
        E. Legs usually very long and slender; thorax not distinctly divided into three segments. (*Harvestmen.*) p. 19. PHALANGIDEA.
        EE. Legs moderately long; head distinct from thorax; thorax distinctly divided into three segments. p. 16. SOLPUGIDA.

AA. Abdomen unsegmented.
B. Abdomen joined to the cephalothorax by a short, narrow stalk. (*Spiders.*) p. 20.....ARANEIDA.
BB. Abdomen fused with the cephalothorax. (*Mites.*) p. 42. ACARINA.

Order SCORPIONIDA (Scor-pi-on'i-da).

The Scorpions.

With the scorpions (Fig. 8), the body is divided into a compact, unsegmented cephalothorax, and a long, segmented abdomen. The abdomen is divided into two portions: a broad pre-abdomen, consisting of seven segments; and a slenderer tail-like division, the post-abdomen, consisting of five segments. At the end of the post-abdomen there is a large poison-sting, which appears like a segment. The mandibles and the palpi are provided with pincers. As the palpi are very large, with stout pincers, they resemble in a striking manner the great claws of lobsters. The cephalothorax bears from three to six pairs of eyes. Scorpions breathe by means of lung sacs, of which there are four pairs, opening on the lower side of the third to the sixth abdominal segments.

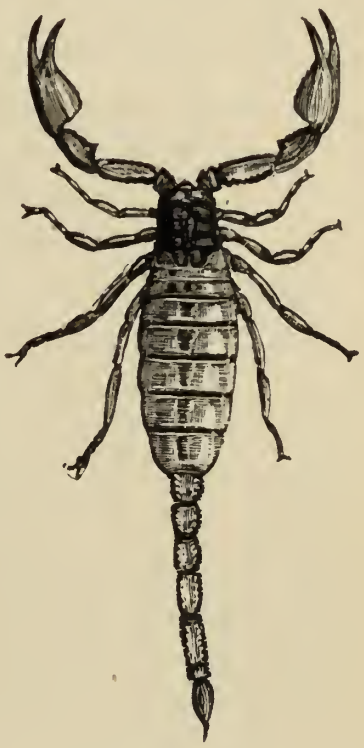

FIG. 8.—A Scorpion.

Full-grown scorpions possess a pair of comb-like organs on the lower side of the second abdominal segment. The function of these organs is not yet known.

The sexes of scorpions differ in that the male has broader pincers and a longer post-abdomen. Scorpions do not lay eggs, the young being developed within the mother. After the birth of the young, the mother apparently shows great regard for them, carrying them about with her for

some time, attached by their pincers to all portions of her body.

Scorpions live in warm countries. They are common in the southern portion of the United States, but are not found in the North. They are nocturnal, remaining concealed during the day, but leaving their hiding-places at dusk. When they run the post-abdomen is bent upwards over the back. They feed upon spiders and large insects, which they seize with the large pincers of their palpi, and sting to death with their caudal poison sting.

The sting of a scorpion rarely if ever proves fatal to man, although the larger species, which occur in the Tropics, produce serious wounds.

Nearly twenty species are known from North America.

Order SOLPUGIDA (Sol-pu'gi-da).

The Jointed Spiders.

The members of this order differ from all other Arachnida in having the head separate from the thorax, and in having the thorax composed of three distinct segments, as with insects. The mandibles are very large, and are furnished with strong pincers. The palpi are shaped like the legs, and are said to be used in locomotion. The first of the four pairs of true legs, like the palpi, are not furnished with claws, and are used as palpi. There are only two eyes. Respiration is effected by means of tracheæ, which open through three pairs of spiracles, situated in the first thoracic and the second and third abdominal segments.

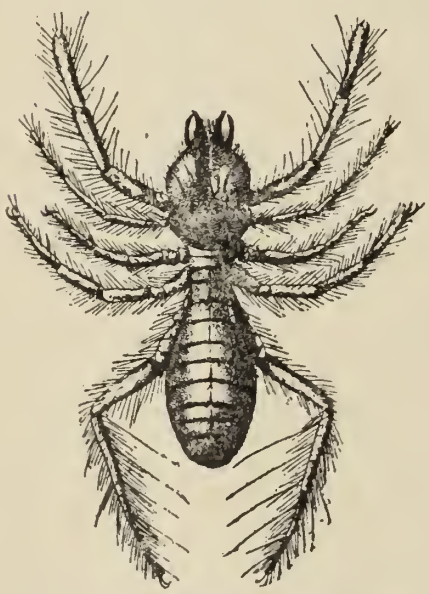

FIG. 9.—A Jointed-spider, *Datames dilatata*. (After Putnam.)

Only a few species of Solpugida occur in the United States, and specimens of these are rarely found. So far

as is known, our species are nocturnal, remaining concealed during the day. They prey upon small insects, and are believed to be harmless. Figure 9 will serve to show the appearance of these curious animals. The popular name, jointed-spiders, is suggested by the segmented condition of the abdomen.

Order PSEUDOSCORPIONES (Pseu-do-scor-pi'o-nes.)

The Pseudoscorpions.

The pseudoscorpions (Fig. 10) are small Arachnida, which resemble scorpions in the form of their body, except that the hinder part of the abdomen is not narrow, as is the post-abdomen of scorpions, and they have no caudal poison-sting. The abdomen is broad, flat, and composed of eleven segments, or in some cases of only ten.

FIG. 10.—A Pseudoscorpion.

The pseudoscorpions possess only one or two pairs of eyes, and in some, eyes are wanting. They breathe by means of tracheæ, which open through two pairs of spiracles on the lower side of the second and third abdominal segments.

These little scorpion-like creatures live under stones, beneath the bark of trees, in moss, and in the dwellings of man, between the leaves of books, etc. They run rapidly, sidewise and backwards; and feed on mites and small insects. They are often found attached to insects, especially to flies; but they probably do not feed on these large insects, but merely use them as means of rapid locomotion.

The pseudoscorpions occur in the Northern States as well in the South.

Order PEDIPALPI (Ped-i-pal'pi).

The Whip-scorpions.

These strange creatures are found only in the extreme southern part of our country, being tropical animals. In

their general form they have some resemblance to scorpions. They can be easily distinguished by the form of the front legs, which are greatly elongated, and have the tarsi broken up into many small segments; this gives these legs a more or less whip-lash-like appearance. In one family the abdomen also bears a whip-lash-like appendage.

The mandibles are furnished with claws; the palpi are very large and armed with strong spines, and the abdomen is distinctly separated from the thorax. The order includes two families, both of which are represented in the United States.

Family THELYPHONIDÆ (Thel-y-phon′i-dæ).

The Tailed Whip-scorpions.

This family is represented in the United States by only a single species, the Giant Whip-scorpion, *Thelyphonus giganteus* (The-lyph′o-nus gi-gan-te′us). This species measures when full grown from four to five inches in length. Figure 11 represents one less than natural size. These whip-scorpions are greatly feared on account of their supposed venomous powers, but it is probable that there is no foundation for this fear. Although it has been stated often that their bites are poisonous, we can find no direct evi-

FIG. 11.—*Thelyphonus giganteus.*

dence that it is so. They destroy their prey by crushing it with their palpi.

Family PHRYNIDÆ (Phryn'i-dæ).

The Tailless Whip-scorpions.

This family is represented in our fauna by the genus *Phrynus* (Phry'nus), the members of which are smaller than the Giant Whip-scorpion. In this family the front legs are even more whip-lash-like than in the preceding family; the whole body is relatively shorter and broader; the abdomen is joined to the thorax by a slender stalk, and the tail-like appendage is lacking.

Order PHALANGIDEA (Phal-an-gid'e-a).

The Harvestmen, or Daddy Long Legs.

The Harvestmen are very common in most parts of the United States. They are well known to children in this country under the name Daddy Long Legs, but as this name is also sometimes applied to Crane-flies, Harvestmen is preferable. In some sections of the country the Harvestmen are known as Grandfather Graybeards.

Most Harvestmen can be recognized by their very long and slender legs (Fig. 12), although some species have

FIG. 12.—The Striped Harvestman.

comparatively short ones. The cephalothorax is indistinctly if at all segmented. The abdomen is short, broad, consists

of six segments, and is without a tail-like appendage; it is broadly joined to the cephalothorax.

The eyes of the Harvestmen are two in number, and are situated on a prominent tubercle near the middle of the cephalothorax. The mandibles are pincer-like. The maxillæ are large, and so opposed as to act as jaws; their palpi are four-jointed, and are small compared with the palpi of the preceding orders; they resemble in form and function the palpi of insects. The members of this order breathe by tracheæ, which open by a single pair of spiracles, on the lower side of the body at the junction of the cephalothorax and abdomen.

The Harvestmen feed on small insects, especially Aphids, and are perfectly harmless. They are said to devour their prey, chewing it with their maxillæ, and swallowing it, instead of merely sucking out the blood, as do most other Arachnida.

Although the Harvestmen have stilt-like legs, they do not raise the body much above the ground when they walk, but carry it quite near their feet, with the middle part of their legs high in the air. They are said to pounce upon their prey as does a cat upon a mouse, and seize it with their palpi as if with hands.

It is a common practice with children to catch these creatures and say to them, "Grandfather Graybeard, tell me where the cows are, or I'll kill you." As the poor frightened animal points its legs in all directions in its frantic efforts to escape, it usually earns its freedom; but too often it is not without the loss of one or more legs.

Order ARANEIDA (Ar-a-ne'i-da).

The Spiders.

The Spiders differ from other Arachnida in having the abdomen unsegmented and joined to the cephalothorax by a short, narrow stalk. The cephalothorax is also un-

segmented; and the abdomen bears at its end organs for spinning silk (Fig. 13).

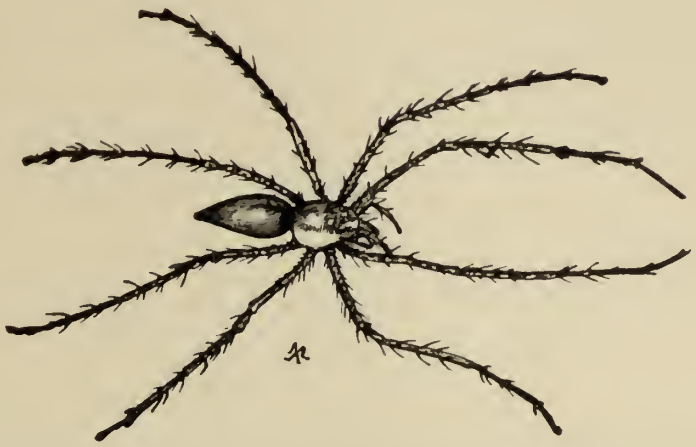

FIG. 13.—*Pencetia viridans.* (From the Author's Report on Cotton Insects.)

The mandibles (Fig. 14, *md*) consist of two segments, a strong basal one and a claw-shaped terminal one, at the tip of which a poison gland opens (Fig. 15). It is by means of these organs that spiders kill their prey. The palpi are leg-like in form, but differ greatly according to sex. In the female the last segment of the palpus resembles a foot of the spider, and is usually armed with a well-developed curved claw. But in the male the corresponding segment is more or less enlarged, and very complicated in structure (Fig. 16). The greater number of spiders have four pairs of eyes (Fig. 17), but there may be

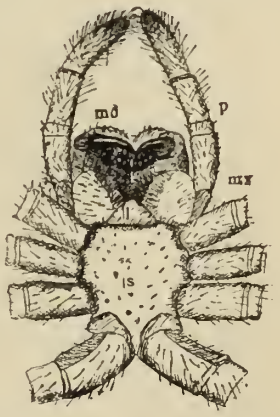

FIG. 14.—Lower side of cephalothorax of a spider; *md*, mandible; *mx*, maxilla; *p*, palpus; *l*, lower lip; *s*, sternum.

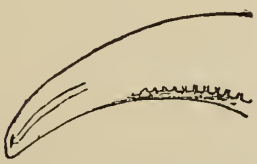

FIG. 15.—Tip of claw of mandible of spider.

FIG. 16.—Maxilla and palpus of male house-spider.

FIG. 17.—Head of spider, showing eyes and mandibles.

only one, two, or three pairs; and certain cave spiders are blind. Spiders breathe by means of lung-sacs, of which there are one or two pairs; and some have tracheæ also. The lung-sacs open on the lower side of the abdomen near its base, and between them is the opening of the reproductive organs. The tracheæ open through a single spiracle near the hind end of the body, just in front of the spinning organs.

The spinning organs, which are situated near the end of the abdomen, consist of two or three pairs of *spinnerets*. These appendages (Fig. 18) are more or less finger-like in form, and sometimes jointed. Upon the end of each spinneret there are many small tubes, the *spinning tubes*, from which the silk is spun (Fig. 19). Some spiders have as many as one hundred and fifty or two hundred of these spinning-tubes on each spinneret. The silk is in a fluid state while it is within the body, but it hardens as soon as it comes in contact with the air.

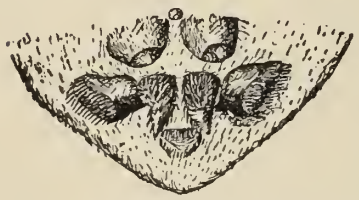

FIG. 18.—End of abdomen of spider, showing six spinnerets spread apart; in front of these is the spiracle, and behind them the opening of the alimentary canal.

Ordinarily the tips of the spinnerets are brought close together, so that all the minute threads that emerge from the numerous spinning tubes unite to form a single thread. This, however, may be so delicate as to be invisible, except in a favorable light. Sometimes a spider will spread its spinnerets apart, and thus spin a broad ribbon-like band. We have observed a spider seize a large grasshopper which was entangled in its web, and, rolling it over two or three times, completely envelop it in a sheet of silk spun from its spread-apart spinnerets.

FIG. 19. A group of spinning-tubes, greatly enlarged.

In the construction of their web some spiders make use of two kinds of silk. One of these is dry and inelastic; the other, viscid and elastic. This fact can be easily seen by examining an orb-web. If the spiral line which forms

the greater part of the web be touched, it will adhere to the finger, and will stretch, when the finger is withdrawn, to several times the original length. But if one of the radiating lines or a portion of the outer framework be touched, it will neither adhere to the finger nor be stretched. If the spiral line be examined with a lens, it will be found to bear numerous bead-like masses of viscid matter (Fig. 20); this explains its adhesiveness.

It is supposed that the two kinds of silk are spun from different spinnerets, and that the viscid silk comes from the front pair. When this silk is first spun the viscid matter forms a continuous layer of liquid on the outside of it. But very soon this layer breaks up into the bead-like masses—in a way similar to that in which the moisture on a clothes-line in a foggy day collects into drops.

Spiders of the two families *Dictynidæ* and *Uloboridæ* have spinning organs differing from those of all other

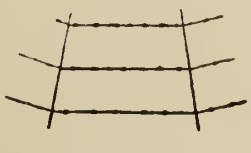

FIG. 20.—Viscid silk from an orbweb.

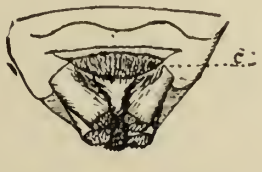

FIG. 21.—Spinnerets of a Dictynid spider. The middle pair of spinnerets are concealed by the first pair. *c*, cribellum.

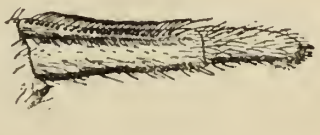

FIG. 22.—Last two segments of hind leg of spider, showing calamistrum.

spiders. They have in front of the usual spinnerets an additional organ, which is named the *cribellum* (cri-bel'lum) (Fig. 21). This bears spinning-tubes like the other spinnerets, but these tubes are much finer. These spiders have also on the metatarsus of the hind legs one or two rows of curved spines: this organ is the *calamistrum* (cal-a-mis'trum) (Fig. 22). By means of the calamistrum these spiders comb from the cribellum a band of loose threads, which form a part of their webs.

Spiders make use of silk in the construction of their webs or snares, in the building of tubes or tents within which they live, in the formation of egg-sacs, and in locomotion.

Fig. 23 represents the large egg-sac of one of the orb-weavers. This is made in the autumn, and contains at that season a large number of eggs—five hundred or more. These eggs hatch early in the winter; but no spiders emerge from the egg-sac until the following spring. If egg-sacs of this kind be opened at different times during the winter, as was done by Dr. Wilder, the spiders will be found to increase in size but diminish in number as the season advances. In fact, a strange tragedy goes on within these egg-sacs: the stronger spiders calmly devour their weaker brothers, and in the spring those which survive emerge sufficiently nourished to fight their battles in the outside world.

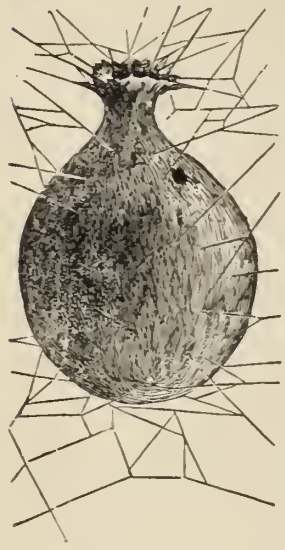

FIG. 23.—Egg-sac of *Argiope riparia*. (From Wilder.)

The egg-sacs of the different species of spiders vary

FIG. 24.—Egg-sac of *Nephila plumipes*. (From Wilder.)

greatly in form. In some, as in that figured above, the outer covering is very dense, while in others the outer part con-

sists of loose flossy silk (Fig. 24). One of the most common kinds is very flat, silvery in color, and is firmly attached to stones lying upon the ground (Fig. 25).

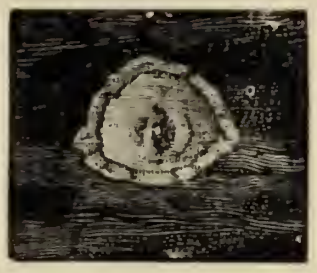

FIG. 25.—Egg-sac of a Drassid.

Every one knows that a spider wishing to descend to some place beneath it simply fastens a line to the object which it is upon and then drops boldly off, regulating the rate of its descent by spinning the line rapidly or slowly; when the spider wishes to return, it has only to climb up the same line.

Frequently spiders pass from point to point in a horizontal direction by means of silken bridges. These are formed in this way: The spider spins out a thread, which is carried off by a current in the air. After a time the thread strikes some object and adheres to it; then the spider pulls the line tight, and fastens it where it is standing. It then has a bridge, along which it can easily run.

But more remarkable than either of these uses of silk for locomotion is the fact that many spiders are able to travel long distances, hundreds of miles, through the air by means of these silken threads—

"sailing mid the golden air
In skiffs of yielding gossamere."—(*Hogg.*)

The Aëronautic Spiders, or Flying Spiders, as they are more commonly called, are frequently very abundant, especially in warm autumn days. At such times innumerable threads can be seen streaming from fences, from bushes, and the tips of stalks of grass, or floating through the air. The flying spider climbs to some elevated point, which may be merely the tip of a stalk of grass, and then, standing on the tips of its feet, lifts its body as high as it can, and spins out a thread of silk. This thread is carried up and away by a current of air. When the thread is long enough the force of the air current on it is sufficient to buoy the spider up. It

then lets go its hold with its feet and sails away. That these spiders travel long distances in this manner has been shown by the fact that they have been seen floating through the air at sea far from land.

Representatives of nearly thirty families of spiders have been found in the United States. But some of these families include only rare species, and others are represented by so few species that we cannot discuss them here. The greater number of our spiders belong to the eleven families described below. The following table will aid the student in separating these families.

TABLE FOR SEPARATING THE PRINCIPAL FAMILIES OF SPIDERS.

A. Claw of the mandibles moving vertically; four lung-slits present. (*Tarantulas.*) p. 27 ..... THERAPHOSIDÆ.

AA. Claw of the mandibles moving horizontally; only two lung-slits present, but with a single spiracle or a pair of spiracles also.

B. Eyes equal or nearly equal in size, and usually arranged in two rows.

C. Feet furnished with two claws (Fig. 28). Spiders which do not spin webs for catching prey.

D. Second pair of legs not so long as the fourth pair.

E. Maxillæ with a concavity or furrow (Fig. 29). Spiders which live on the ground. p. 29 .... DRASSIDÆ

EE. Maxillæ convex (Fig. 32). Spiders which live chiefly in silken tubes on bushes. p. 30 ..... CLUBIONIDÆ.

DD. Second pair of legs as long as or longer than the fourth pair. (*The crab-spiders.*) p. 40 ..... THOMISIDÆ.

CC. Feet furnished with three claws (Fig. 38). Spiders which spin webs for catching prey.

D. The caudal pair of spinnerets very long, and two-jointed. Spiders which make irregular webs with a tube or hiding-place at one side, from which they run on the upper surface of the web, to catch their prey. p. 30 ..... AGALENIDÆ.

DD. All of the spinnerets short.

E. With cribellum and calamistrum. Spiders making webs in which there are curled threads, or double threads.

F. The side eyes not as far apart as the middle eyes; a considerable space between the eyes and the front edge of the head. Spiders making irregular webs. p. 32. DICTYNIDÆ.

FF. The side eyes as far or farther apart than the middle eyes; eyes very close to the front edge of the head. Spiders making regular webs. (*Uloborus.*) p. 38. ULOBORIDÆ.

EE. With neither cribellum nor calamistrum. Spiders making webs in which there are no curled threads.

F. Eyes not near the front edge of the head, the space between the two being greater than that occupied by the eyes (Fig. 37). Spiders that spin irregular webs, in or near which they live, hanging back downwards. p. 34. THERIDIIDÆ.

FF. Eyes near the front edge of the head, the space between the two being less than that occupied by the eyes (Fig. 42). Spiders that make regular webs, consisting chiefly of lines radiating from the centre, and a spiral or looped sticky line. p. 35.....EPEIRIDÆ.

BB. The eyes unequal in size and arranged in three or four rows.

C. With cribellum and calamistrum. Spiders which make webs. (*Hyptiotes.*) p. 38..... .....ULOBORIDÆ.

CC. With neither cribellum nor calamistrum. Spiders which do not spin webs for catching prey.

D. The largest eyes not in the front row. (*Running spiders.*) p. 40.....LYCOSIDÆ.

DD. The largest eyes in the front row. (*Jumping spiders.*) p. 42..... .....ATTIDÆ.

Family THERAPHOSIDÆ (Ther-a-phos'i-dæ).

The Tarantulas and the Trap-door Spiders.

Those who live in the warmer parts of our country know well the large spiders commonly called Tarantulas. These are the giants among spiders, some of them being the largest known; but some species of this family are not very large. They are dark-colored, hairy spiders, and can be distinguished from the other families mentioned here by the fact that the

claw of the mandibles works up and down instead of sidewise.

The members of this family do not construct true webs, but they dig long tubes in the earth, which they line with silk, or line their hiding-places in clefts in trees or elsewhere with a layer of silk. They live only in warm countries.

One of the best known of the Tarantulas is *Eurypelma hentzii* (Eu-ryp'el-ma hentz'i-i). This species occurs in the South and in the Middle West, and is the largest of our spiders (Fig. 26). Several closely allied species are found in California.

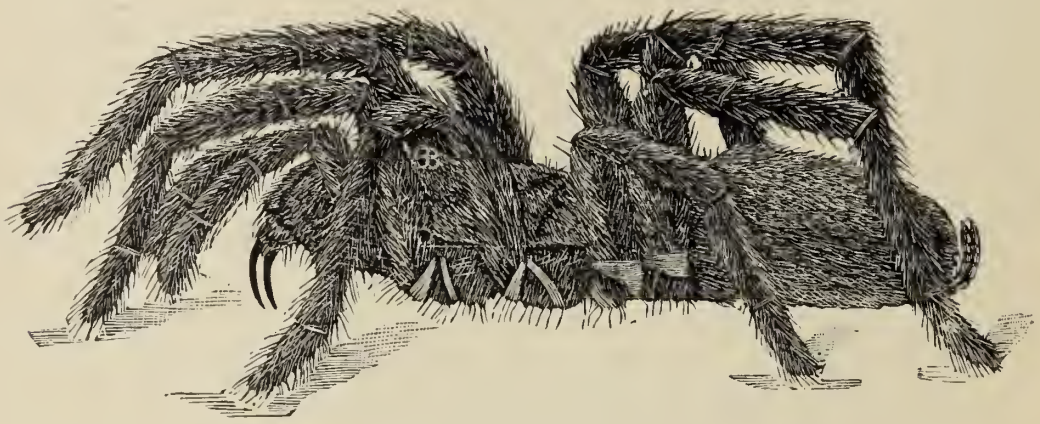

FIG. 26.—A Tarantula, *Eurypelma hentzii*.

But the members of this family that have attracted most admiration on account of their habits are the Trap-door Spiders. These dig a tube in the ground, as do many other members of this family; but this tube is lined with a denser

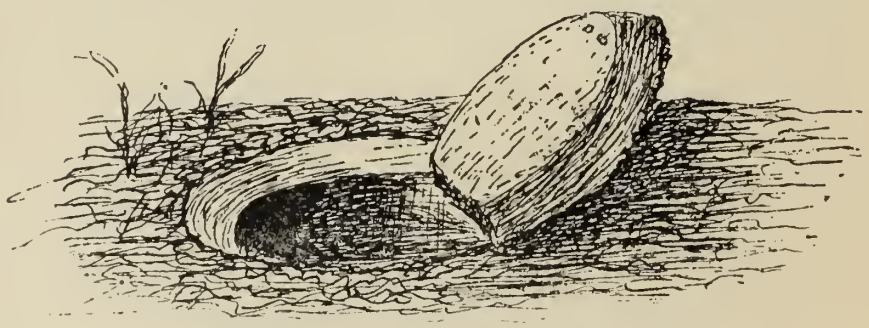

FIG. 27.—Entrance to nest of a trap-door spider.

layer of silk, and is provided with a hinged lid, which fits the opening of the tube with wonderful accuracy (Fig. 27).

The spider hides in this nest when not seeking its prey. Some species take the precaution to build a branch to their nest, and to provide this branch with a door. As this door forms a part of one side of the main tube, it is not likely to be observed by any creature which may find its way past the first door of the nest.

Several species of Trap-door Spiders occur in the Southern and Southwestern States.

Family DRASSIDÆ (Dras'si-dæ).

The Drassids, or Tube Weavers in part.

There are certain dark-colored spiders that spin no web, but wander about at night in search of prey, and hide under leaves and stones during the day-time. Many of them make silken tubes, in which they hide in winter or while moulting or laying eggs. Hence they have been termed Tube Weavers, a name which is also applied to certain other spiders. We will therefore call the members of this family the *Drassids* (Dras'sids).

In this family the body is long, and is usually flattened above. It is carried near the ground in walking. The legs are rather short and stout; the second pair are not longer than the fourth, and the feet are furnished with only two claws (Fig. 28). The eyes are in two nearly straight rows, and the maxillæ are concave or furnished with a furrow (Fig. 29).

FIG. 28.—Foot of a Drassid.

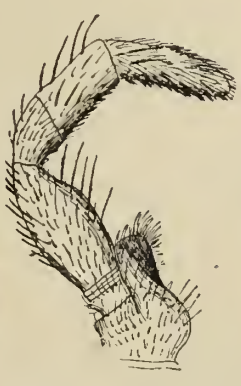

FIG. 29.—Maxilla of a Drassid.

FIG. 30.—*Drassus saccatus.*

One of the most common species in the East is *Drassus saccatus* (Dras'sus sac-ca'tus) (Fig. 30). It lives under stones, in a large bag of silk, in which the

female stays with her egg-sac. In early summer a male and female live together in the nest.

Family CLUBIONIDÆ (Clu-bi-on'i-dæ).

The Clubionids, or Tube Weavers in part.

There may be found during summer, in flat tubular nests on plants, usually in rolled leaves, spiders that spin no webs to entrap their prey. These spiders very closely resemble the Drassids in structure, but are usually lighter in color, with the legs a little longer and more slender, and the abdomen more nearly cylindrical (Fig. 31). They are also distinguished by the form of the maxillæ, which are convex (Fig. 32). These spiders belong to the family Clubionidæ. As we have no appropriate common name for these spiders, they may be called the *Clubionids* (Clu-bi-on'ids).

FIG. 31. — *Clubiona canadensis.*

FIG. 32.—Maxilla of a Clubionid.

During the winter the Clubionids hide under bark or stones, and make tubular nests in these places.

Family AGALENIDÆ (Ag-a-len'i-dæ).

The Funnel-web Weavers.

Even the most careful observers seldom realize what an immense number of spider-webs are spun upon the grass in the fields. But occasionally these webs are made visible in the early morning by the dew which has condensed upon them. At such times we may see the grass covered by an almost continuous carpet of silk.

The greater number of the webs seen at such times are of the form which we term funnel-webs. They consist of a concave sheet of silk, with a funnel-shaped tube at one side,

and numerous lines extending in all directions to the supporting spears of grass (Fig. 33). The tube serves as a

FIG. 33.—Web of Grass Spider, *Agalena nævia*.

hiding-place for the owner of the web; from this retreat the spider runs out on the upper surface of the web to seize any insect that alights upon it. The tubes open below, near the roots of the grass; so that the spider can escape from it if a too formidable insect comes upon the web.

The funnel-web weavers (family *Agalenidæ*) are long-legged, brown spiders, in which the head part of the cephalothorax is higher than the thoracic part, and distinctly separated from it by grooves or marks at the sides. The eyes are usually in two rows, but in *Agalena* the middle eyes of both rows are much higher than the others. The feet have three claws. The posterior pair

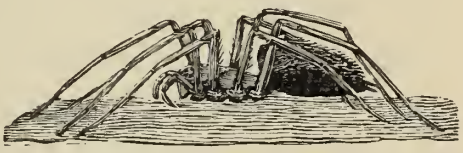

FIG. 34.—*Agalena nævia*.

of spinnerets are two-jointed, and usually longer than the others.

The common grass spider, which abounds in all parts of the United States, is *Agalena nævia* (Ag-a-le'na næ'vi-a (Fig. 34).

Family DICTYNIDÆ (Dic-tyn'i-dæ).

The Curled-thread Weavers with Irregular Webs.

The Dictynids (*Dic-tyn'ids*).

Certain spiders are remarkable for using two kinds of silk in the formation of their webs. Thus, as explained later, the Orb Weavers build the framework of their orbs of dry and inelastic threads, and attach to this framework a thread which is sticky and elastic; while most spiders which make irregular webs use only one kind of silk. There are, however, certain species of irregular web-weavers which use two kinds of silk. One of these is a plain thread like that spun by other spiders, and the other is a peculiar curled thread or a delicate band of tissue in which there are curled threads.

The curled-thread weavers represent two families, one of which makes irregular webs; the other, those which are of definite form. The first of these is the *Dictynidæ*.

The curled-thread or tissue-like band is made in the same way by both families. It is composed of silk spun from a special spinning-organ, situated in front of the ordinary spinnerets, and named the *cribellum* (cri-bel'lum); and is combed into its peculiar form by means of a comb of stiff hairs, the *calamistrum* (cal-a-mis'trum), which is borne by the metatarsus of the hind legs (see page 23). In making the curled thread the spider turns one of its hind legs under the abdomen so that the calamistrum is just under the cribellum, and the foot rests on the other hind leg. It then moves its hind legs back and forth rapidly, so that the calamistrum combs out from the spinning-tubes, and at the same time tangles, a band of fine threads.

This band of tangled or curled threads is easily seen in the webs of these spiders, being wider than the ordinary threads and white in color. In old webs it becomes conspicuous by the large amount of dust which it collects. Figure 35 shows the appearance of this band when magnified, and the way in which it is attached to the plain threads.

FIG. 35.—Curled thread of a Dictynid, enlarged.

Our more common Dictynids make webs of various shapes, on fences, under stones, in holes in rotten logs, and

FIG. 36.—Web of a Dictynid, on a dead branch of Ceanothus, somewhat enlarged.

on plants. These webs are especially common among the flowers of Golden-rod and other plants having clusters of

small flowers (Fig. 36), and exhibit a slight degree of regularity.

Family THERIDIIDÆ (Ther-i-di'i-dæ).

The Cobweb Weavers.

Many are the kinds of webs spun by different spiders. Some of them, as the orb-webs and the funnel-webs, delight us with their wonderful regularity of form; while others appear to be a mere shapeless maze of threads. Such are the structures whose presence in the corners of our rooms torment thrifty housewives, and which are disrespectfully termed *cobwebs*.

The cobweb weavers (Family *Theridiidæ*) are small spiders with unusually slim legs. The space between the eyes and the front edge of the head is greater than the

FIG. 37.—Face of house spider.

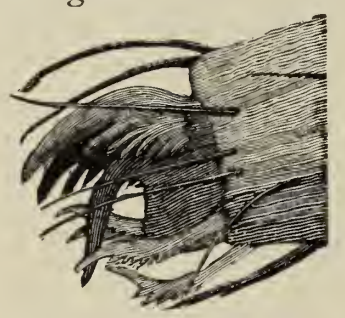

FIG. 38.—Foot of spider with three claws.

FIG. 39.—*Mimetus interfector.*

region occupied by the eyes (Fig. 37); the eyes are in two rows; and the feet are furnished with three claws (Fig. 38). This family includes many species, being in fact the largest of all of the families of spiders. Figure 39 represents a widely distributed species.

Although the house spiders are the most familiar members of this family, the greater number of species spin their webs in the fields on bushes. These webs usually consist of a flat or curved sheet, under which the spider hangs back downward. This sheet is supported by threads running in all directions to the neighboring objects. Frequently there is a large number of these supporting threads above the web, which serve the additional purpose of impeding the flight of

insects, and causing them to fall into the web, where they are caught.

Some of these spiders do not remain in their webs, but have a nest in a neighboring crack or corner, from which they rush to seize their prey. And sometimes there is a funnel-shaped tube leading to this nest. But these spiders differ from the true funnel web weavers in running back downwards on the lower side of their web.

Family EPEIRIDÆ (E-pei'ri-dæ).

The Orb Weavers.

Few if any of the structures built by lower animals are more wonderful than the nets of orb-weaving spiders, but these beautiful objects are so common that they are often considered hardly worthy of notice. If they occurred only in some remote corner of the earth, every one would read of them with interest.

The nets of the different species of orb weavers differ in the details of their structure, but the general plan is quite similar. There is first a framework of supporting lines. The outer part of this framework is irregular, depending upon the position of the objects to which the net is attached; but the more central part is very regular, and consists of a number of lines radiating from the center of the net (Fig. 41). All of these supporting lines are dry and inelastic. But there is spun upon the radiating lines in a very regular manner a thread which is sticky and elastic (Fig. 20, p. 23). Usually this sticky thread is fastened to the radiating lines so as to form a spiral, but a few species make nets in which this thread is looped back and forth.

Many of the orb weavers strengthen their nets by spinning a zigzag ribbon across the center. This ribbon is made by spreading the spinnerets apart so that the minute threads from the spinning tubes do not unite to make a single thread, as is usually the case.

Some of the orb weavers live in their nets hanging head

downwards, usually near the center of the net ; others have a retreat near one edge of the net, in which they hang back

FIG. 41.—Partially completed web of Epeira.

downwards. While resting in these retreats they keep hold of some of the lines leading from the net, so that they can instantly detect any jar caused by an entrapped insect.

When an insect in its flight touches one of the turns of the sticky line, the line sticks to it ; but it stretches so as to allow the insect to become entangled in other turns of the line. If it were not for this elasticity of the sticky line, most insects could readily tear themselves away before the spider had time to reach them.

In making its web an orb weaver first spins a number of lines extending irregularly in various directions about the place where its orb is to be. This is the outer supporting framework. Often the first line spun is a bridge between two quite distant points. This is done as described on p. 25. Having a bridge across the place where the web is to be, it is an easy matter for the spider to stretch its other lines where it wishes them. In doing this it fastens a thread to one point, and then walks along to some other point, spin-

ning the thread as it goes, and holding it clear of the object on which it is walking by means of one of its hind legs. When the second point is reached the thread is pulled tight and fastened in place.

After making the outer framework the radiating lines are formed. A line is stretched across the space so as to pass through the point which is to be the center of the orb. In doing this the spider may start on one side, and be forced to walk in a very roundabout way on the outer framework to the opposite side. It carefully holds the new line up behind it as it goes along, so that it shall not become entangled with the lines on which it walks; one or both hind feet serve as hands in these spinning operations. The spider then goes to the point where the centre of the orb is to be, and fastening another line there, it walk back to the outer framework, and attaches this line an inch or two from the first. In this way all of the radiating lines are drawn. The next step is to stay these radii by a spiral line which is begun at the center, and attached to each radius as it crosses it. The turns of this spiral are as far apart as the spider can conveniently reach, except at the center of the web. All of the threads spun up to this stage in the construction of the web are dry and inelastic. The spider now proceeds to stretch upon this framework a sticky and elastic line, which is the most important part of the web, the other lines being merely a framework to support it. In spinning the sticky line the spider begins at the outer edge of the orb, and passing around it fastens this line to each radius as it goes. Thus a second spiral is made. The turns of this spiral are placed quite close together, and the first spiral, which is merely a temporary support, is destroyed as the second spiral progresses. Figure 41 represents a web in which the second spiral is made over the outer half of the radii. In this figure, *aa* represents the temporary stay-line; *bb*, the sticky spiral; and *cc*, the fragments of the first spiral hanging from the radii.

FIG. 42.—Face of Epeira.

FIG. 43.—Foot of Epeira.

The orb weavers (Family *Epeiridæ*) are usually plump spiders, the abdomen being large, and often nearly spherical. The space between the eyes and front edge of the head is less than the region occupied by the eyes (Fig. 42). The eyes are arranged in two rows. The front legs are longer than the others. The feet have three claws (Fig. 43), and the spinnerets are all short. In some species of this family the male is much smaller than the female.

Family ULOBORIDÆ (U-lo-bor'i-dæ).

The Curled-thread Weavers with Regular Webs.

The Uloborids (*U-lo-bo'rids*).

We have already described the thread-curling habits of the Dictynids (p. 32), and the curious organs called cribellum and calamistrum (Fig. 44), by which these curled threads are made (p. 23). Similar organs and a similar habit are possessed by the spiders of the family *Uloboridæ*. These spiders, however, make webs which are regular in form. There are only two genera belonging to this family in the United States; but as the webs made by these are very different, we will describe both.

FIG. 44.—Calamistrum of Hyptiotes.

The Triangle Spider, *Hyptiotes cavatus* (Hyp-ti'o-tes ca-va'tus).—This spider is common all over New England and the Middle States, and has been found as far to the southwest as Texas. Its web is most often found stretched between the twigs of a dead branch of pine or spruce. At first sight this web appears like a fragment of an orb web (Fig. 45); but a little study will show that it is complete. The accompanying figure, by Dr. Wilder, who first described

the habits of this spider (see *Popular Science Monthly*, 1875), illustrates the form of the web. It consists of four plain lines corresponding to the radiating lines of an orb web, and a series of double cross lines, which are spun by the cribellum and calamistrum. From the point where the radiating lines meet a strong line extends to one of the supporting twigs. Near this twig the spider rests, pulling the web tight

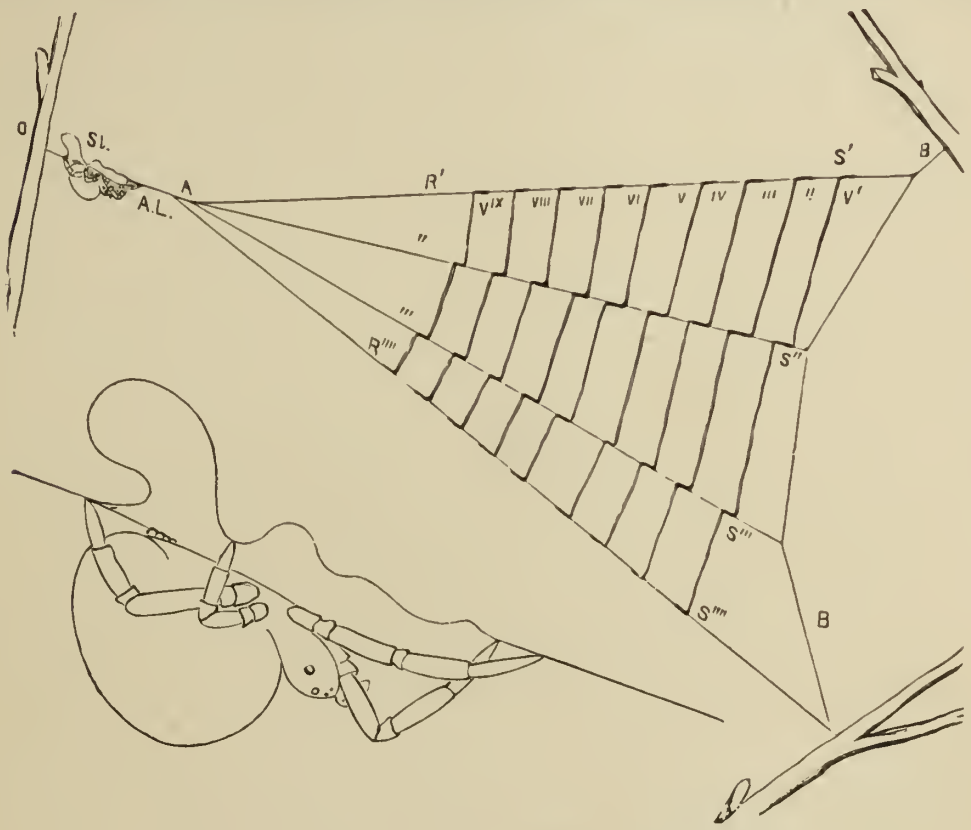

FIG. 45.—Web of *Hyptiotes cavatus*. (From Wilder.)

so that there is some loose line between its legs, as shown in the enlarged figure. When an insect becomes entangled in one of the cross lines, the spider suddenly lets go the loose line so that the whole web springs forward, and the insect is entangled in other cross threads. The spider then draws the web tight and snaps it again. This may be repeated several times before the spider goes out upon the web after its prey.

Uloborus (U-lob'o-rus).—The spiders of this genus make round webs which resemble at first sight those of the Orb Weavers; but they differ from the ordinary orb webs in that

the spiral thread is made of curled or hackled silk. These webs are nearly horizontal, and are usually made between stones or in low bushes. The spiders of this genus are not common, but they are widely distributed. They have not, however, been reported as yet from the Pacific coast.

Family THOMISIDÆ (Tho-mis'i-dæ).

The Crab Spiders.

There are certain spiders which are called crab spiders, on account of the short and broad form of the body, and the curious fact that they can walk more readily sidewise or backward than forward.

These spiders spin no webs, but lie in wait for their prey. They live chiefly on plants and fences, and in the winter hide in cracks and under stones and bark. Most of the species are marked with gray and brown, like the bark upon which they live. Some species conceal themselves in flowers, where they lie in wait for their prey. These are brightly colored, like the flowers they inhabit; so that insects visiting flowers may alight within reach of a spider before seeing it.

In this family the legs are turned outward and forward more than downward; so that the body is carried close to the ground. The second pair of legs are as long as or longer than the fourth pair. The eyes are small, nearly equal in size, and arranged in two rows.

FIG. 46.— *Misumena vatia.*

One of the best-known members of this family is the female of *Misumena vatia* (Mi-su'me-na va'ti-a). This is milk-white, with sometimes a light crimson mark on each side of the abdomen, and is found within flowers (Fig. 46).

Family LYCOSIDÆ (Ly-cos'i-dæ).

The Running Spiders.

Every collector of insects who has searched for specimens under stones and logs is familiar with the large, dark-colored, hairy spiders often found in these places. These

spiders frequently attract especial attention by dragging after them a large gray ball (Fig. 47); this is the egg-sac, which the female carries about with her attached to her spinnerets. These spiders run swiftly; and as they depend

FIG. 47.—*Lycosa* and egg-sac.

on the use of their legs for the capture of their prey, they are well termed Running Spiders.

These spiders resemble in general appearance and in habits the Tarantulas of the South and the West. But none of our species attain the great size of some of the Tarantulas, and in the Running Spiders the claw of the mandibles moves horizontally instead of vertically.

In this family the body is hairy and usually much longer than broad. The eyes differ markedly in size, and are arranged in three or four rows. The larger eyes are not in the front row. The legs are rather long and quite stout.

Like the Tarantulas, some of the Running Spiders build tubular nests in the ground, which they line with silk. Sometimes the entrance to these nests is concealed by small sticks and leaves, and sometimes the spider builds a regular turret over the entrance of its tube (Fig. 48). These nests are used merely as retreats, the spiders wandering forth in search of their prey.

FIG. 48.—Entrance to nest of Turret Spider, *Lycosa arenicola*. (After Marx.)

The larger members of our common species belong to the genus *Lycosa* (Ly-co'sa). These drag after them their egg-sacs as described above; and

when the young hatch they climb on their mother's back, and are carried about for a time. The females of the genus *Dolomedes* (Dol-o-me'des), which also belongs to this family, carry their egg-sac in their mandibles until the young are ready to hatch. At this time the mother fastens the egg-sac in a bush, and spins a web of irregular threads about it, among which the young spiders remain for a time.

Family ATTIDÆ (At'ti-dæ).

The Jumping Spiders.

The Jumping Spiders are of medium size, with a short body and short stout legs (Fig. 49). They are common on plants, logs, fences, and the sides of buildings. They are very apt to attract attention by their peculiar appearance; their short stout legs, bright colors, conspicuous eyes, and quick, jumping movements being very different from those of ordinary spiders.

FIG. 49.—*Attus nubilus.* (From the Author's Report on Cotton Insects.)

The eyes are arranged in three or four rows; the front middle pair are the largest, and are very conspicuous. These self-possessed spiders are able to stare an ordinary observer out of countenance. They move sidewise or backward with great ease, and can jump a long distance. They make no webs except nests in which they hide in winter or when moulting or laying eggs.

In certain members of this family the body is longer than in the typical forms, and ant-like in appearance.

Order ACARINA (Ac-a-ri'na).

The Mites.

In this order the abdomen is unsegmented and fused with the thorax, giving the entire body a more or less sac-like appearance. In many the body is marked by numerous

transverse, fine lines, which are so impressed as to appear like the divisions between minute segments (Fig. 52). The majority of mites are very small; but some, as certain Ticks, are of considerable size.

With the exception of a single family the members of which bring forth living young, all mites are produced from eggs. As a rule, the newly-hatched mites have only three pairs of legs; but a fourth pair are added during growth. In *Phytoptus*, which infests plants, there are only two pairs of legs.

The mode of life of the different members of this order varies greatly: some are parasitic upon animals; others infest living plants; and many feed upon dead animal or vegetable matter, thus acting as scavengers.

Among the mites that are parasitic upon animals are the various Ticks, which are very common in the warmer parts of our country. Figure 50 represents the Cattle-tick of the Southern States. It should be remembered in this connection that the so-called Sheep-tick is a true insect, belonging to the order Diptera.

FIG. 50. — The Cattle-tick, female.

The Itch-mite is a well-known parasite, infesting man and causing the disease known as the itch. The sensation characteristic of this disease is due to the burrowing of the mites in the skin; and the efficiency of sulphur ointment in checking this disease is due to the fact that by the use of it the mites are killed. Figure 51 represents an itch-mite greatly enlarged.

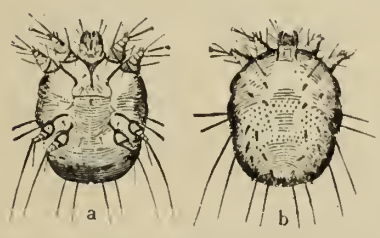

FIG. 51.—An Itch-mite: a, from below; b, from above.

Parasitic mites are frequently found attached to insects; a common species occurs beneath the wings of locusts.

The best known of the mites that infest plants is the one commonly called the Red Spider. This lives upon house-plants; and in the warmer parts of the country, where there

is a dry season, it infests fruit-trees in the open air. As it thrives only in a dry atmosphere, it can be subdued upon house-plants by a liberal use of water. When it occurs upon plants in the open air it can be combated with any of the washes found useful in destroying scale insects.

Some of the mites that infest plants produce galls. These galls are of various forms, but differ from those produced by gall-flies (Family *Cynipidæ* of the Order *Hymenoptera*) in having open mouths, from which the young mites escape.

A common disease of the pear, known as the pear-leaf blister, is produced by a four-legged mite, *Phytoptus pyri* (Phy-top'tus py'ri) (Fig. 52). The blisters characteristic of

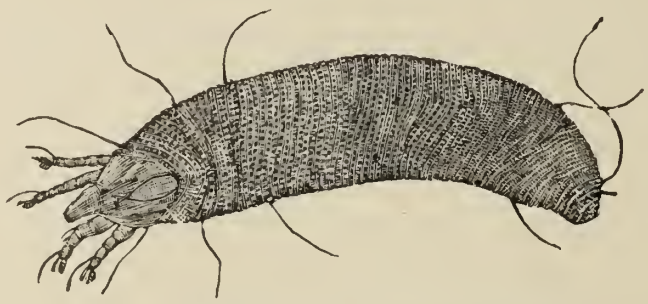

FIG. 52.—*Phytoptus pyri*, greatly enlarged.

the disease are swellings of the leaf, within which there is a cavity affording a residence for the mites. Figure 53 repre-

FIG. 53.—Diagram of gall of *Phytoptus pyri*: *g*, gall; *n*, *n*, normal structure of leaf; *o*, opening of gall; *e*, eggs. (After Soraur).

sents a section of a leaf through one of these galls. Here the leaf is seen to be greatly thickened at the diseased part. On the lower side there is an opening through which the mite that started the gall entered, and from which young

mites developed in the gall can escape, in order to start new galls. In addition to the swelling of both surfaces of the leaf its internal structure is seen to be modified. In some parts there is a great multiplication of the cells, and in others a large part of the cells have been destroyed. Two eggs of mites are represented in this gall. As the season advances, and the galls become dry and brownish or black, the thickening of the leaf becomes less marked. In fact, in some cases there is a shrinkage of the parts affected. Fig-

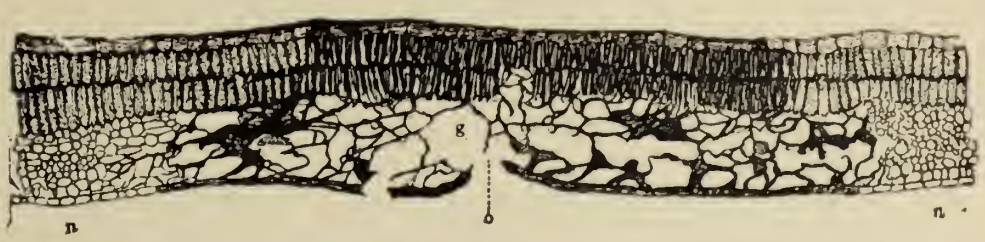

FIG. 54.—Section of leaf showing structure of gall in autumn: *g*, gall; *n*, *n*, uninjured part of leaf; *o*, opening of gall.

ure 54 represents a section through a leaf collected and studied in October.

Among the scavenger mites there are some that infest food products. Thus mites are sometimes found in cheese, in sugar, and in preserved meats.

Class MYRIAPODA (Myr-i ap'o-da).

The Centipedes and the Millipedes.

The members of this class are air-breathing Arthropods, in which the head is distinct from the thorax, and the thorax and abdomen form a continuous region, with from six to two hundred segments, each bearing a pair of legs. The head bears a single pair of antennæ.

The thousand-legged worms, as they are commonly called, are well-known and generally feared creatures. But few students find them attractive subjects of study; nevertheless it is well to know something about them, for some of them are dangerous animals, and some are harmless. A few species are injurious to agriculture, while others are to be

classed among our friends. And all of them are of interest to the naturalist as representatives of a distinct type of Arthropods.

If we omit certain small and rather uncommon forms, the Myriapods may be classed in two orders; one consisting of the Centipedes, the other of the Millipedes.

Order CHILOPODA (Chi-lop'o-da).

The Centipedes.

The centipedes can be recognized at a glance by the fact that each segment of the body bears a single pair of legs (Fig. 55). The body is usually flattened, and the antennæ are long and many-jointed.

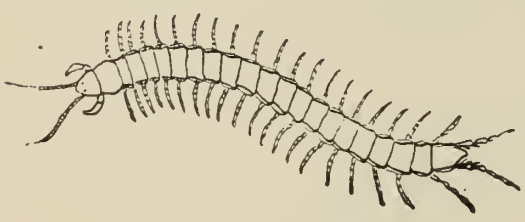

FIG. 55.—A Centipede.

Many species of centipedes are venomous. The poison glands open through the claws of the first pair of legs, which are bent forward so as to act with the mouth parts. These creatures abound in all parts of the United States; those which are found in the North are comparatively small, and rarely, if ever, inflict serious injury to man; but the larger species, which occur in the warmer regions, are said to be extremely venomous.

The centipedes are predaceous, feeding on insects; they usually live under stones, logs, and bark. There is one species, *Cermatia forceps* (Cer ma'ti-a), which has very long legs, and only fifteen pairs of them, which is often found running on the walls of houses, especially in the Southern States. We have never heard of this centipede biting a human being, and as it feeds upon insects, especially cockroaches, it may be regarded as a welcome visitor in houses.

Order CHILOGNATHA (Chi-log'na-tha).

The Millipedes.

The millipedes differ from the centipedes in having two pairs of legs on each of the body segments except the first three. The body in most of them is not flattened as with the centipedes, and the antennæ are comparatively short and few jointed (Fig. 56).

FIG. 56.—A Millipede.

The millipedes, as a rule, live in damp places and feed on decaying vegetable matter. They are harmless, except that occasionally they feed upon growing plants.

CHAPTER III.

Class HEXAPODA (Hex-ap'o-da).

The Insects.

The members of this class are air-breathing Arthropoda, with distinct head, thorax, and abdomen. They have one pair of antennæ, three pairs of legs, and usually one or two pairs of wings in the adult state.

There are about us on every side myriads of tiny creatures that are commonly passed unnoticed, and even when observed, they are usually thought to be unworthy of serious consideration. But all life is linked together in such a way that no part of the chain is unimportant. Frequently upon the action of some of these minute beings depends the material success or failure of a great commonwealth. The introduction and spread of a single species of insect (the Cottony-cushion Scale) in California threatened the destruction of the extensive orchards of that State; thousands of trees perished. The introduction of a few individuals of a particular kind of Lady-bug (*Vedalia cardinalis*), which feeds upon this pest and multiplies rapidly, soon checked the evil, and has nearly removed the pest from the State.

But insects are of interest to us for other reasons than the influence they may have upon our material welfare; the study of them is a fruitful field for intellectual growth. It is not a small matter to be able to view intelligently the facts presented by the insect world, to know something of what is going on around us. And so rich is this field that no one gains more than a mere smattering concerning it.

We know as yet comparatively little about the minute structure of insects; the transformations and habits of the greater number of species have not been studied; and the blood-relationship of the various groups of insects is very imperfectly understood. If, therefore, one would learn something of the action of the laws that govern the life and development of organized beings, and at the same time experience the pleasure derived from original investigation, he cannot find a better field than is offered by the study of insects.

But it is not necessary that one should have the tastes and leisure required for careful scientific investigation in order to profit by this study. It can be made a recreation, a source of entertainment when we are tired, a pleasant occupation for our thoughts when we walk. Any one can find out something new regarding insect architecture—the ways in which these creatures build nests for themselves or for their young. It is easy to observe remarkable feats of engineering, examples of foresight, wonderful industry, unremitting care of young, tragedies, and even war and slavery.

The abundance of insects makes it easy to study them. They can be found wherever man can live, and at all seasons. This abundance is even greater than is commonly supposed. The number of individuals in a single species is beyond computation: who can count the aphids or the scale-bugs in a single orchard, or the bees in a single meadow?

Not only are insects numerous when we regard individuals, but the number of species is far greater than that of all other animals taken together. The number of species in a single family is greater in several cases than the number of stars visible in a clear night.

The word *insect* is often applied incorrectly to any minute animal; and even among naturalists there is some lack of uniformity in its use. Some writers include under this term the Arachnida and Myriapoda, as well as the Six-footed Insects. But the great majority of entomologists restrict

the term to the Hexapoda, and it is in this sense that we use it.

The name *Hexapoda* is from two Greek words: *hex*, six; and *pous*, foot. It refers to the fact that the members of this order differ from other Arthropods in the possession of only six feet.

Insects breath by means of a system of air-tubes (tracheæ) which extends through the body. This is true even in the case of those that live in water and are supplied with gill-like organs (the tracheal gills; see p. 75). The head is distinct from the thorax, and bears a single pair of antennæ; in these respects they are closely allied to the Myriapods. But they can be easily distinguished by the number of their feet, and, usually, also by the presence of wings.

The Metamorphoses of Insects.

Nearly all insects in the course of their lives undergo remarkable changes in form. Thus the butterfly, which delights us with its airy flight, was at one time a caterpillar; the bee, which goes so busily from flower to flower, lived first the life of a clumsy, footless grub; and the graceful fly was developed from a maggot.

In the following pages considerable attention will be given to descriptions of the changes through which various insects pass. It is our wish in this place merely to define certain terms which are used in describing these changes.

Development without Metamorphosis.—In one of the orders of insects, the Thysanura, the young insect just hatched from the egg is of the same form as the adult insect. These insects merely grow larger, without any more marked change in form than takes place in our own bodies during our life. They are said, therefore, to develop without metamorphosis.

Incomplete Metamorphosis.—There are many insects which undergo a striking change of form during their life, although the young greatly resembles the adult. Thus a young locust just out from the egg can be easily recognized as a locust.

It is of course much smaller than the adult, and is not furnished with wings. Still the form of the body is essentially the same as that of the adult (Fig. 57). (The hair-line above the figure indicates the natural size of the insect.) After a time rudimentary wings appear; and these increase

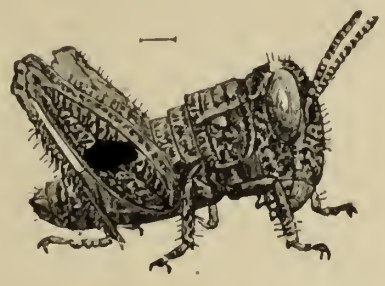

FIG. 57.—Nymph of *Melanoplus*, first stage. (After Emerton.)

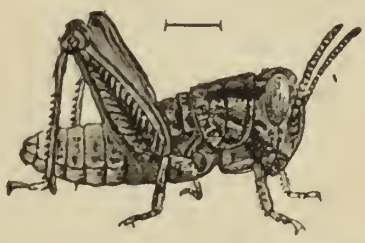

FIG. 58.—Nymph of *Melanoplus*, second stage. (After Emerton.)

FIG. 59.—Nymph of *Melanoplus*, third stage. (After Emerton.)

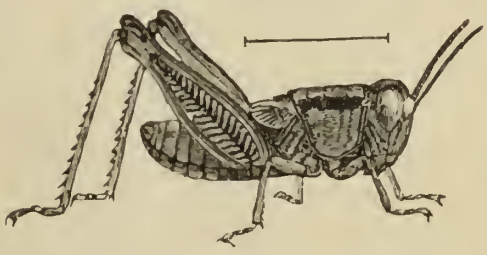

FIG 60.—Nymph of *Melanoplus*, fourth stage. (After Emerton.)

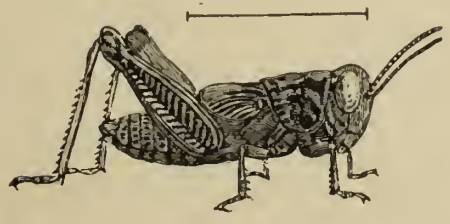

FIG. 61.—Nymph of *Melanoplus*, fifth stage. (After Emerton.)

FIG. 62.—*Melanoplus*, adult.

in size from time to time till the adult state is reached (Figs. 57 to 62). During this development there is no point at which the insect passes into a quiescent state corresponding to the chrysalis state of a butterfly. Those insects which, like the locust, when they emerge from the egg resemble in form the adult, but still undergo some change, are said to undergo an incomplete metamorphosis. In other words, after leaving the egg they do not undergo a complete change of form.

Complete Metamorphosis.—Still other insects, like the but-

terflies, beetles, bees, and flies, leave the egg in an entirely different form from that which they assume when they reach maturity. A butterfly begins its active life as a caterpillar. It feeds and grows, and when full grown changes to a chrysalis. In this stage it has very little resemblance to a caterpillar. After a time there bursts forth from the chrysalis shell the butterfly, which looks very little like the chrysalis, and still less like the caterpillar from which it came. In a similar way, from the egg laid by a fly upon a piece of meat there hatches, not a fly, but a footless, worm-like maggot. This when fully grown changes to a quiescent object corresponding to the chrysalis of a butterfly. Later from this object there escapes a winged fly like that which laid the egg. Those insects, like the butterflies and flesh-flies, which when they emerge from the egg bear almost no resemblance in form to the adult insect, are said to undergo a complete metamorphosis. In other words, the change of form undergone by the insect is a complete one.

How Insects grow—Molting.—The skin of an insect is hardened more or less by a horny substance known as *chitine* (chi'tine). This hardening usually occurs to a much greater extent in adult insects than it does in the young. But in all, the skin becomes so firm that it cannot stretch enough to allow for the growth of the insect. The result is, that from time to time an insect's skin becomes too small for it, and must be shed. But before this is done a new skin is formed beneath the old one; then the old skin bursts open, and the insect crawls forth, clothed in a soft skin, which stretches to accommodate the increased size of the animal. Very soon, however, this new skin becomes hardened with chitine, and after a time it in turn must be shed. This shedding of the skin is termed *molting*, and the cast skin is some-

FIG. 62*a*.—Exuviæ of nymph of Dragon-fly.

times referred to as the *exuviæ* (ex-u′vi-æ). Insects differ greatly as to the number of times they molt: many species molt only four or five times, while others are known to molt more than twenty times. Figure 62*a* represents the cast skin of a Dragon-fly clinging to a reed.

The Egg.—This is the first stage in the existence of any insect, although in some few instances the egg remains in the body of the mother till it hatches. But almost always the eggs are laid by the mother insect on or near the food which gives nourishment to the young. Many of the most interesting habits of insects are connected with the care of the eggs by the parent. The eggs may have smooth oval shells; but often the shells are beautifully ribbed and pitted (Fig. 63), and sometimes they are ornamented with spines, and are frequently exquisitely colored.

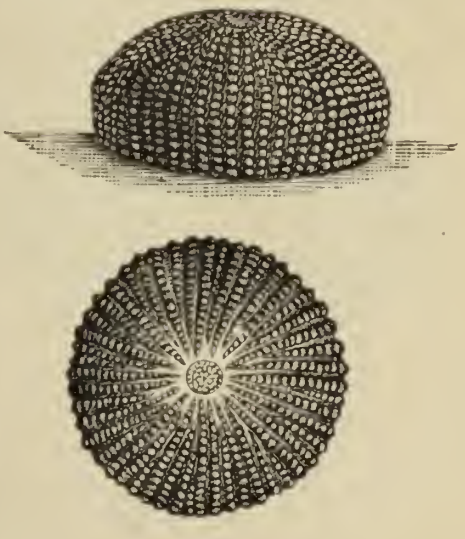

FIG. 63.—Egg of Cotton-worm, greatly enlarged. (From the Author's Report on Cotton Insects.)

The Larva.—This is the second stage of an insect's life, and is the form that hatches from the egg. Familiar examples of larvæ are caterpillars, maggots, and grubs (Fig. 64).

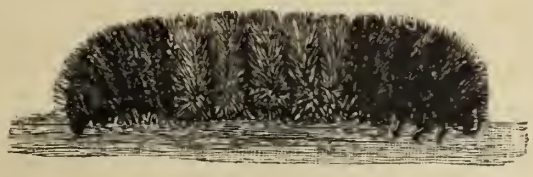

FIG. 64.—A caterpillar, the larva of a moth.

In fact, nearly all the creatures commonly known as worms are larvæ of insects. Away from the ocean we find but few worms, except earthworms, leeches, "hair-snakes," and worm parasites in the intestines of men and animals. Nearly all the rest, except millipedes and centipedes, are larvæ of insects, and finally change to forms with wings.

The larval stage is devoted to growth; the sole business of a larva being to eat and grow. All molting, because of increased size, is done in the larval stage, later molts are simply for change of shape.

The Pupa.—This is the third stage in the life of an insect, and is ordinarily a period of inaction, except that rapid and wonderful changes go on within the body. Very few pupæ, like those of mosquitoes, are active. Usually pupæ have no power of moving around, but many of them can squirm when disturbed. When the last skin of the larva is thrown off the pupa is revealed; it is an oblong object, and frequently apparently headless and footless. In many pupæ the skin is a shiny covering like porcelain. If a pupa be examined closely the antennæ and legs and wings may be seen; these are folded up closely and soldered to the breast in the case of the moths and butterflies (Fig. 65), but free in case of the bees, ants, and beetles.

FIG. 65.—A pupa of a large moth.

The Chrysalis.—This term is often applied to the pupa of a butterfly. The word is derived from a Greek word meaning gold, and came into use because of the golden dots and markings on many of the butterfly pupæ.

The Cocoon.—Many larvæ, especially those of moths, when full grown, spin about the body a silken case, so that when they change to helpless pupæ they may be protected from enemies, and from rain and snow; these silken cases are called cocoons. They are frequently made within a rolled leaf (Fig. 66), or beneath grass and rubbish on the ground, or in cells below the ground. Some hairy caterpillars make cocoons largely of their own hairs, which they fasten together with a film of silk.

The Nymph.—The terms larva and pupa are only applied to the early stages of those insects that have a com-

plete metamorphosis; for in the case of other insects there is no distinct pupa stage. When reference is made to the young of an insect that undergoes an incomplete metamor-

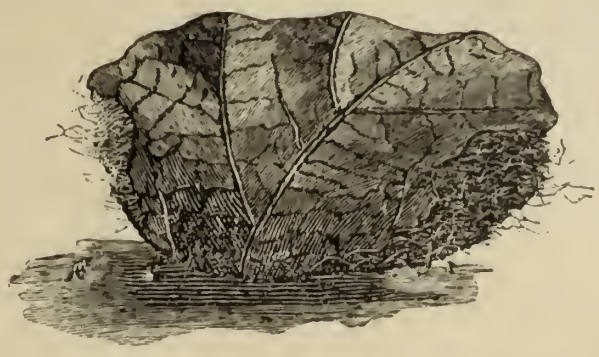

FIG. 66.—A large cocoon within a rolled leaf.

phosis it is called a *nymph*. This term is applied to all stages of such an insect from the time they hatch from the egg until they shed their skin for the last time. When a nymph first hatches it has no signs of wings; but after it molts several times two projections appear on each side of the thorax. These projections become larger and larger, and more wing-like in form with each successive molt. Usually the change in the size of these organs, between the last nymph stage and the adult stage, is much greater than that of any previous molt. With the nymphs of certain families, dragon-flies, crickets, grasshoppers, and locusts, the front pair of developing wings extend back beneath the hind pair instead of covering them; and by this inverted position of the wings the nymphs may be distinguished from the adults, even in those cases where the adults have only rudimentary wings.

The Adult.—This is the last stage or the mature form of the insect. Almost all adult insects except Thysanura have wings, although there are numerous exceptions to the rule; for there are many cases where wings have been lost through disuse. An insect never grows after it reaches the adult stage, and therefore never molts. There is a popular belief that a small fly will grow into a large fly, but this is not true, for after any insect gets its perfect wings it can

grow no larger, except that in case of females the body may be distended by the growth of eggs within it. While many adults eat more or less, it is only to sustain life, and not for growth. Indeed, many adult insects take very little food, and some have lost their mouth-parts entirely, through disuse. The adult stage usually lasts for a considerably shorter time than the larval or nymph stages. In fact, it seems planned in the economy of nature that the grown-up insects should live only long enough to lay eggs, and thus secure the perpetuation of the species.

The External Anatomy of Insects.

The subject of insect anatomy is separated into two divisions: one, treating of the structure of the body-wall or skeleton; the other, of the internal organs. The former is termed *external anatomy;* the latter, *internal anatomy.*

In our own bodies we find a central framework or skeleton, about which are arranged the muscles, blood-vessels, nerves, and other organs. But insects are constructed on an entirely different plan: with them the supporting skeleton is outside, and the muscles, nerves, and other organs are within this skeleton. The difference can be well seen if the figure showing the internal structure of the leg of a May-beetle (Fig. 67) be compared with one of our own limbs, either arm or leg.

Fig. 67.—Leg of May-beetle. (After Straus-Durckheim.)

The body of an insect is built on the same plan as are its legs. The outside of the body is more or less firm, being hardened by chitine; and this firm outer wall supports the muscles and other organs, thus serving as a skeleton. The skeleton is therefore, in general outline, a hollow cylinder.

This hardening of the body-wall is not continuous, but takes place in a series of more or less regular, ring-like bands, which give the well-known segmented appearance characteristic of insects, and the animals closely allied to them. Between the hardened ring-like segments the body-wall remains soft and flexible. In this way provision is made for the various motions of the body. The ring-like nature of the segments of the body is best seen in larvæ (Fig. 68), and in the hinder part of an adult insect (Fig. 69). The movements of the legs, antennæ, and certain other appendages are provided for in the same way; each one is a cylinder made up of several segments, and between these segments the wall of the cylinder remains flexible.

Fig. 68.—A Larva.

Fig. 69.—A Mole Cricket.

When a single segment of the body is examined, the hardened portion is not found to be a continuous ring, but is seen to be made up of several portions more or less movable upon each other. Such a hardened portion of the body-wall is termed a *sclerite* (scle′rite).

The sclerites constitute the greater part of the body-wall, the soft membranous portions separating them being in most cases narrow. Usually these narrow portions are mere lines; they are then called *sutures* (sūt′ūrs).

Frequently the sutures become entirely effaced. We are therefore often unable to distinguish certain sclerites in one species of insect which we know to exist in another. In such cases the effaced sutures are said to be *obsolete*.

If the central portion or thorax of an adult insect be examined, numerous sclerites and sutures can be observed (Fig. 70).

The subject of external anatomy of insects consists very largely in a study of the sclerites of which the different segments of the body and of its appendages are composed. This part of the subject is quite difficult, and will not be discussed here. It is treated at length in a more advanced text-book by the senior author.*

FIG. 70.—Side-view of Locust with wings removed

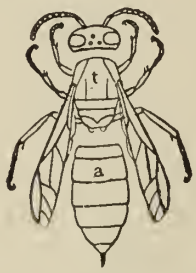

FIG. 71.—Wasp, with head, thorax, and abdomen separated.

The segments of the body in a fully developed insect are grouped into three regions: head, thorax, and abdomen (Fig. 71). In the larval state this grouping of the segments is not well shown.

The Head and its Appendages.

The head is the first of the three regions of the body. It is supposed to be formed of several body-segments grown together; but entomologists differ in their views as to the number of segments that have entered into its composition.

The head bears the compound eyes, the simple eyes, the antennæ, and the mouth-parts.

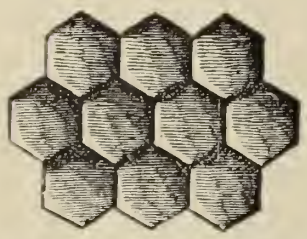

FIG. 72. — Part of compound eye, greatly enlarged.

The Compound Eyes.—On each side of the head of an adult insect is an organ, which is recognized at once as an eye. But when one of these eyes is examined with a microscope it is found to present an appearance very different from that of the eye of higher animals; its surface is divided into a large number of six-sided divisions

* An Introduction to Entomology by John Henry Comstock Published by the Comstock Publishing Co., Ithaca, N. Y.

(Fig. 72). A study of the internal structure of this organ has shown that each of these hexagonal divisions is the outer end of a distinct eye (Fig. 73). Hence what at first appears to be a single eye is really an organ composed of hundreds of eyes; it is termed, therefore, a compound eye. Each of the small eyes of which a compound eye is composed is termed an *ocellus* (o-cel'lus) (plural *ocelli*). The number of ocelli of which a compound eye is composed varies greatly: there may be not more than fifty, as in certain ants, or there may be many thousand, as in a butterfly or a dragon-fly. Compound eyes are not found in larvæ, though they may possess a group of simple eyes on each side of the head.

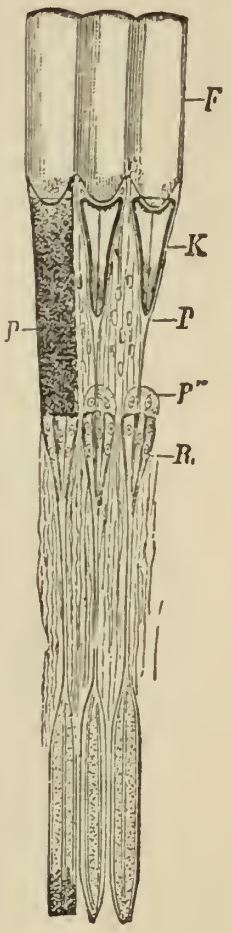

FIG. 73. — Three ocelli, with retinulæ, from the compound eye of a May-beetle. (After Grenacher.) The pigment has been dissolved away from two of them. *F*, corneal facet; *K*, crystalline cone; *p*, pigment-sheath; *P*, chief pigment-cell; *p''*, pigment-cells of the second order; *R*, retinulæ.

The Simple Eyes.—In addition to the compound eyes, many adult insects possess simple eyes. These are situated between the compound eyes. They vary in number from one to four; the most common number is three (see Fig. 71). The simple eyes are usually termed *ocelli;* sometimes, *stemmata* (stem'ma-ta).

When the term *ocelli* is used in descriptive works, if there is nothing in the context to indicate the contrary, it is almost invariably applied to the simple eyes, and not to the elements of the compound eyes. In the same way the term *eye* usually refers to the compound eyes, unless otherwise indicated by the context.

The Antennæ.—The antennæ are a pair of jointed appendages inserted in the head in front of the eyes or between them. They vary in form. In some insects they are thread-like, consisting of a series of similar segments; in others certain segments are greatly modified in form.

The various forms of antennæ are designated by special terms. The more common of these forms are represented in Figure 74. These are as follows:

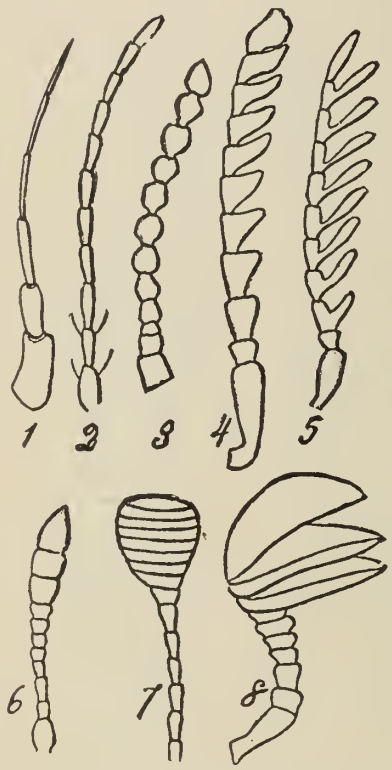

FIG. 74.—Various forms of antennæ.

1. Setaceous (se-ta'ceous) or bristle-like, in which the segments are successively smaller and smaller, the whole organ tapering to a point.

2. Filiform (fil'i-form) or thread-like, in which each segment is of nearly uniform thickness throughout its length; and the antenna as a whole tapers gradually, if at all, towards the tip.

3. Moniliform (mo-nil'i-form) or necklace-form, in which the segments are more or less globose, suggesting a string of beads.

4. Serrate (ser'rate) or saw-like, in which the segments are triangular, and project like the teeth of a saw.

5. Pectinate (pec'ti-nate) or comb-like, in which the segments have long processes on one side, like the teeth of a comb, or on both sides, like a feather.

6. Clavate (cla'vate) or club-shaped, in which the segments become gradually broader, so that the whole organ assumes the form of a club.

7. Capitate (cap'i-tate) or with a head, in which the terminal segment or segments form a large knob.

8. Lamellate (lam'el-late), in which the segments that compose the knob are extended on one side into broad plates.

The Mouth-parts.—No set of organs in the body of an insect vary in form to a greater degree than do the mouth-parts. Thus with some the mouth is formed for biting, while with others it is formed for sucking. Among the biting insects some are predaceous, and have jaws fitted for seizing and

tearing their prey; others feed upon vegetable matter, and have jaws for chewing this kind of food. Among the sucking insects the butterfly merely sips the nectar from flowers, while the mosquito needs a powerful instrument for piercing its victim. In this place the typical form of the mouth-parts as illustrated by the biting insects is described. The various modifications of it presented by the sucking insects are described later, in the discussion of the characters of those insects.

In the biting insects, the mouth-parts consist of an upper lip, the *labrum* (la'brum) (Fig. 75, 8); an under lip, the *labium* (la'bi-um) (Fig. 75, 12); and two pairs of jaws between them. These jaws open sidewise, instead of in a vertical direction, as do the jaws of the higher animals. The upper pair of jaws are called the *mandibles* (man'di-bles) (Fig. 75, 10); the lower pair, the *maxillæ* (max-il'læ) (Fig. 75, 11). There may be also within the mouth one or two tongue-like organs, the *epipharynx* (ep-i-phar'ynx) and *hypopharynx* (hy-po-phar'ynx) (Fig. 75, 13). The epipharynx is attached to the upper wall of the cavity of the mouth, and the hypopharynx to the lower. The position of the hypopharynx is quite analogous, therefore, to that of our tongue.

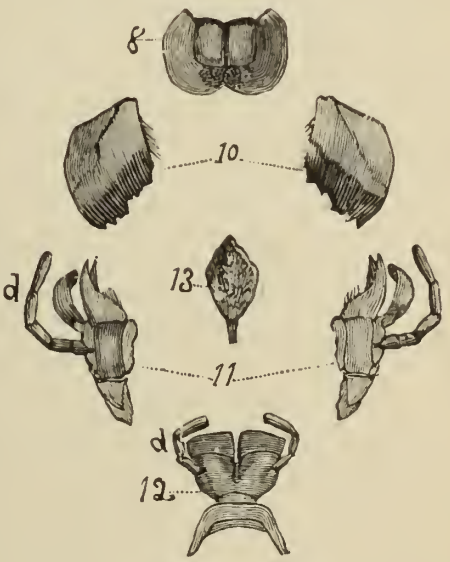

FIG. 75.—Mouth-parts of the Red-legged Locust.

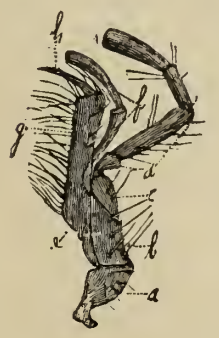

FIG. 76.—Maxilla of a Tiger Beetle.

The mandibles vary much in form, but usually each consists of a single sclerite. The maxillæ of biting insects, on the other hand, are very complicated organs, each composed of several sclerites. Each maxilla bears an appendage consisting of several segments; these

appendages are termed the *maxillary palpi.* In the maxillæ of certain biting insects, as the grasshoppers and the ground beetles, there is an appendage usually consisting of two segments: this is the *galea* (ga'le-a) or *outer lobe.* In some of these insects, as the ground-beetles and the tiger-beetles, the galea is shaped like a palpus, and thus there appears to be two pairs of maxillary palpi (Fig. 76). The labium is furnished with a pair of jointed appendages; these are the *labial palpi* (Fig. 75, 11, *d*).

The Thorax and its Appendages.

The thorax is the second or intermediate region of the body; it is the region that bears, in the adult insect, the organs of locomotion, the legs, and the wings when they are present. This region is composed of three of the body-segments more or less firmly joined together; the segments are most readily distinguished by the fact that each bears a pair of legs. In winged insects, the wings are borne by the second and third segments. The first segment of the thorax, the one next to the head, is named the *prothorax;* the second thoracic segment is the *mesothorax;* and the third, the *metathorax.*

The Legs.—Each leg consists of the following parts, beginning with the one next to the body (see Fig. 77): *coxa*, *trochanter*, *femur*, *tibia*, and *tarsus.* Each of these parts consists of a single segment except that in certain Hymenoptera the trochanter consists of two segments (Fig. 77, *t*), and in most insects the tarsus consists of several segments. The number of segments of the tarsus varies from one to six; the most common number is five. Frequently the first segment of the tarsus is much longer than either of

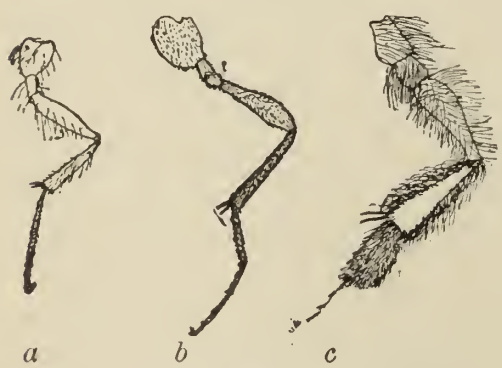

FIG. 77.—Legs of insects: *a*, Wasp; *b*, Ichneumon-fly; *c*, Bee; *t*, trochanter; *m*, metatarsus.

the other segments, and it may also differ greatly in form from them; under such circumstances it is sometimes designated the *metatarsus* (met-a-tar'sus) (Fig. 77, *m*). The last segment of the tarsus usually bears one or two claws.

On the ventral surface of the segments of the tarsus in many insects are cushions of short hairs or of membrane, capable of inflation, or concave plates, which act so as to produce a vacuum, and thus enable the insect to walk on the lower surface of objects. These cushions or plates are called *pulvilli* (pul-vil li). In many insects the pulvillus of the last segment of the tarsus is a circular pad projecting between the tarsal claws. In most descriptive works this is referred to as *the* pulvillus, even though the other pulvilli are well developed. See also page 420.

The Wings.—The two pairs of wings are borne by the mesothorax and metathorax, but either or both pairs may be wanting. Thus the Flies, or *Diptera*, have only the first pair of wings fitted for flight, the second pair being represented by a pair of knobbed threads, the function of which is unknown; and with the Earwigs and Beetles the first pair of wings is wanting, although the mesothorax bears a pair of horny wing covers, which are somewhat wing-like in form, and are commonly described as wings.*

In form an insect's wing is a large membranous appendage, which is thickened along certain lines. These thickened lines are termed the *veins* or *nerves* of the wing; and their arrangement is described as the *venation* or *neuration* of the wings. The thin spaces of the wings which are bounded by the veins are called *cells*. When a cell is completely surrounded by veins it is said to be *closed;* but when it extends to the margin of the wing it is said to be *open*.

The wings of different insects vary greatly in structure,

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* The wing covers or elytra of earwigs and beetles probably correspond to the tegulæ of Hymenoptera and to the patagia of Lepidoptera; that is, they are a pair of the side pieces of the mesothorax, the paraptera, greatly enlarged.

and thus afford excellent distinctions for the purposes of classification. The various parts of the wing have, therefore, received special names. There is considerable lack of uniformity among entomologists as to the names applied to these parts; but we have adopted the set of terms defined below as representing the best usage.

An insect's wing is more or less triangular in outline; it therefore presents three margins: the *costal margin*, or *costa* (Fig. 78, *a*, *b*); the *outer margin* (Fig. 78, *b*, *c*); and the *inner margin* (Fig. 78, *c*, *d*).

The angle at the base of the costal margin (Fig. 78, *a*) is the *humeral angle* (hu'me-ral); that between the costal margin and the outer margin (Fig. 78, *b*) is the *apex* of the wing; and the angle between the outer margin and the inner margin (Fig. 78, *c*) is the *anal angle* (a'nal).

There have been many different sets of names applied to the veins of the wings. Not only have the students of each order of insects had a peculiar nomenclature, but in many cases different students of the same order of insects have used different sets of terms. This condition of affairs was incident to the beginning of the science, the period before the correspondence of the veins in the different orders had been worked out. But now the time has come when it seems practicable to apply a uniform nomenclature to the wing veins of all orders; and the following set of terms is proposed for that purpose.

The principal veins of the wing, those that arise at or near the base of the wing, are termed, beginning with the one lying on the costal margin, the *costa* (cos'ta), the *subcosta*, the *radius* (ra'di-us), the *media* (me'di-a), the *cubitus* (cu'bi-tus), and the *anal veins*. The radius, media, and cubitus are usually branched, and there may be several anal veins.

In certain orders of insects two other veins arising near the base of the wing have been developed: one lying between the media and the radius, the *premedia*; and one lying between the media and the cubitus, the *postmedia*.

The veins are frequently designated by numbers; the following table will indicate the correspondence of the numbers with the names:

I. Costa.
II. Subcosta.
III. Radius.
IV. Premedia.
V. Media.
VI. Postmedia.
VII. Cubitus.
VIII. } Anal.
IX. }
X. }
et al. }

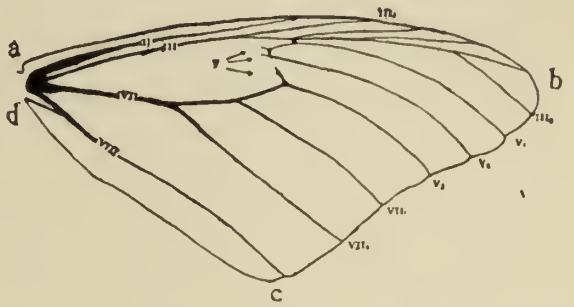


FIG. 78.—Diagram of wing, showing margins, angles, and veins.

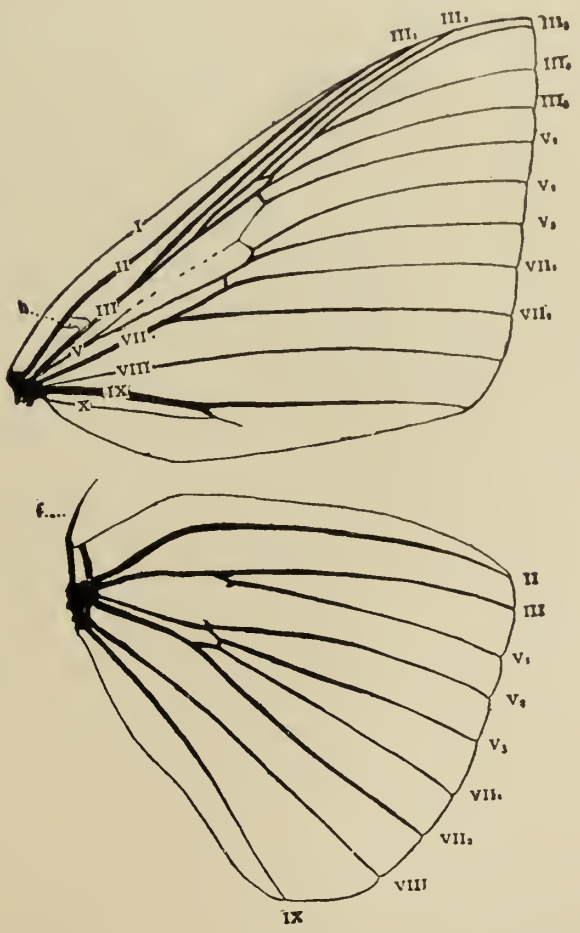


FIG. 79.—Diagram of wing of moth, showing the arrangement of the veins; veins IV and VI are wanting.

The principal veins are indicated by Roman numerals, and when these veins are branched, the branches are indicated by Arabic indices appended to the Roman numeral. Thus the branches of radius are designated as III_1, III_2, III_3, etc. (Fig. 79).

Figure 78 represents the fore-wing of a butterfly (*Danais*), and Figure 79 the two wings of a moth (*Castnia*). In all butterflies and moths veins IV and VI are wanting, and in all butterflies and in many moths the basal part of vein V is also wanting. The arrows in Figure 78 indicate the position of the remnants of this part of vein V. In the hind wing of the moth figured, vein V_1 has become joined to vein III, so that it appears to be a branch of it; and in the butterfly vein V_3 appears to be a branch of vein VII, although a short stump, indicated by the lower arrow, shows its former position, in ancient butterflies, before the loss of the basal part of vein V.

The Abdomen and its Appendages.

The *abdomen* is the third or caudal region of the body. Its segments are more simple, distinct, and ring-like than those of the other regions. The number of segments of which it appears to be composed varies greatly. In the Cuckoo-flies (*Chrysididæ*) there are usually only three or four visible, while in many other insects nine appear. Except in the lowest order of insects (*Thysanura*) the abdomen of the adult bears no locomotive appendages. But many larvæ have fleshy appendages which aid in locomotion: these are termed *prolegs*. In the adult the end of the body in many families is furnished with jointed filaments—the *cerci*, and *caudal setæ*. Frequently also the body is furnished in the male with organs for clasping—the *claspers;* and in the female with saws, piercers, or borers—the *ovipositor*. In the female of certain insects there is a *sting*, a modified ovipositor, which is used as an organ of defence; and the abdomen of plant-lice and certain other insects bears a pair of tubes or tuber-

cles, through which honey-dew is excreted: these are commonly called *honey-tubes*; they are also termed *cornicles*, *nectaries*, or *siphuncles*.

The Internal Anatomy of Insects.

(*For advanced students.*)

As has been shown in the preceding pages, the body-wall serves as a skeleton, being hard, and giving support to the other organs of the body. This skeleton may be represented, therefore, as a hollow cylinder. We have now to consider the arrangement and the general form of the organs contained in this cylinder. For the details of the structure of the internal organs the student is referred to more special works.

The accompanying diagram (Fig. 80), which represents a vertical, longitudinal section of the body, will enable the student to gain an idea of the relative position of some of the more important organs. The parts shown in the diagram are as follows: The body-wall, or skeleton

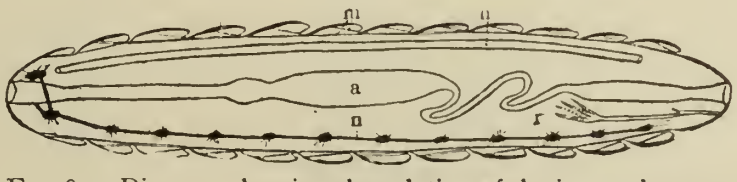
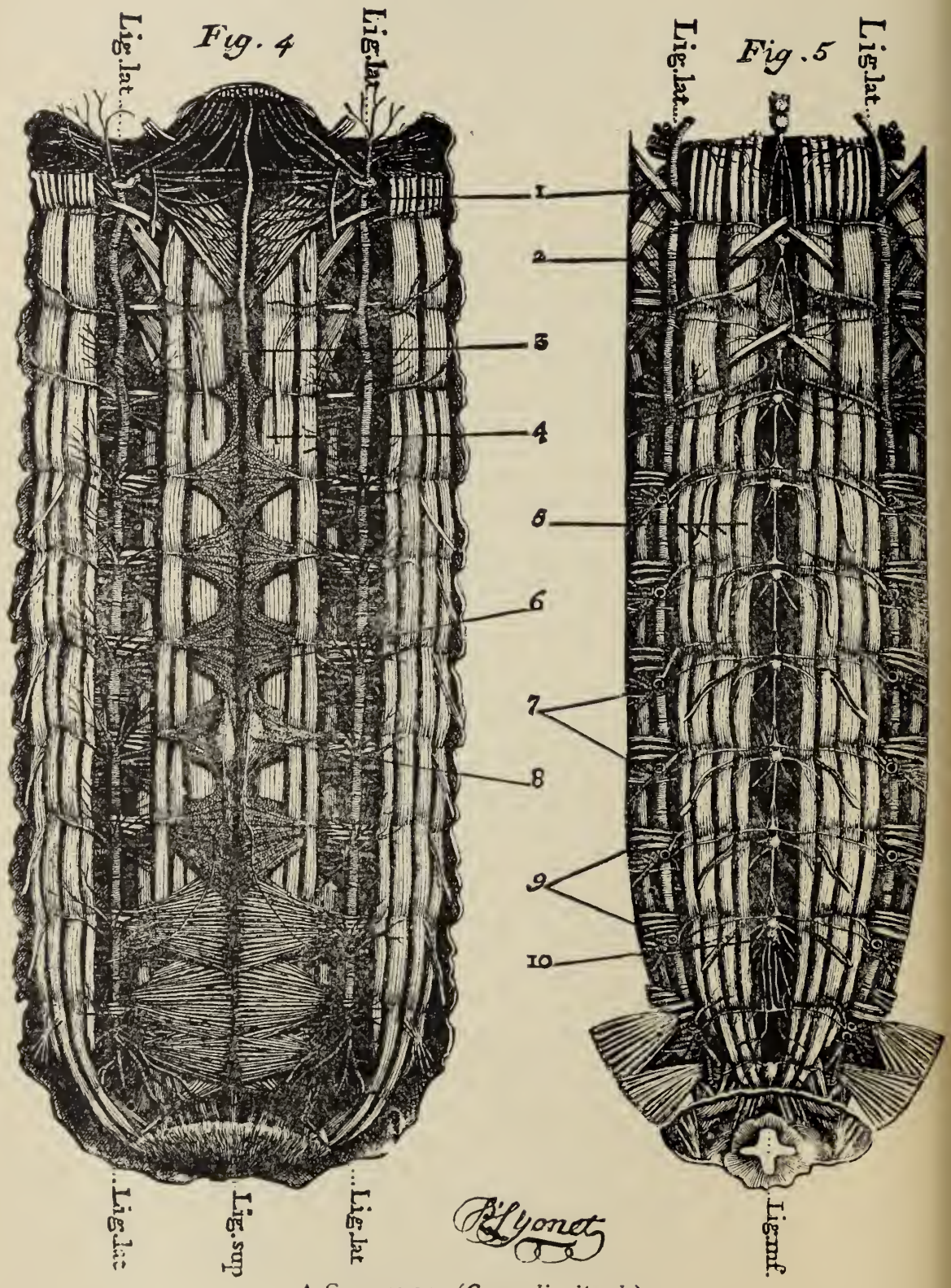


Fig. 80.—Diagram showing the relation of the internal organs.

(*s*); this is made up of a series of overlapping segments; that part of it between the segments is thinner, and is not hardened with chitine, thus remaining flexible and allowing for the movements of the body. Just within the body-wall, and attached to it, are represented a few of the muscles (*m*); it will be seen that these muscles are so arranged that the contraction of those on the lower side of the body would bend it down, while the contraction of those on the opposite side would act in the opposite direction. The alimentary canal (*a*) occupies the centre of the body, and extends from one end to the other. The heart (*h*) is a tube open at both ends, and lying between the alimentary canal and the muscles of the back. The central part of the nervous system (*n*) is a series of small masses of nervous matter connected by two longitudinal cords: one of these masses, the brain, lies in the head above the alimentary canal; the others are situated,

PLATE II.



A CATERPILLAR (*Cossus ligniperda*).
(After Lyonet.)

FIG. 1.—Caterpillar opened on the ventral middle line FIG 2.—Caterpillar opened on the dorsal middle line. 1, principal longitudinal tracheæ; 2, central nervous system; 3, aorta; 4, longitudinal dorsal muscles; 5, longitudinal ventral muscles; 6, wings of the heart; 7, tracheal trunks arising near spiracles; 8, reproductive organs; 9, vertical muscles: 10, last abdominal ganglion.

one in each segment, between the alimentary canal and the layer of muscles of the ventral side of the body; the two cords connecting these masses, or ganglia, pass one on each side of the œsophagus to the brain. The reproductive organs (*r*) lie in the cavity of the abdomen and open near the caudal end of the body. The respiratory organs are omitted from this diagram for the sake of simplicity.

The Muscular System.—We find in insects a wonderfully large number of muscles. Those that move the segments of the body form several layers just within the body-wall. The two figures on Plate II represent two caterpillars which have been split open lengthwise, one on the middle line of the back and one on the opposite side; in each case the alimentary canal has been removed, so that only those organs that are attached quite closely to the body-wall are left. From a study of these figures some idea can be obtained of the number and arrangement of these muscles. It should be borne in mind, however, that only a single layer of muscles is represented in these figures—the layer which would be seen if a caterpillar were opened in the way indicated. When these muscles are cut away many other muscles are found extending obliquely in various directions between these muscles and the body-wall.

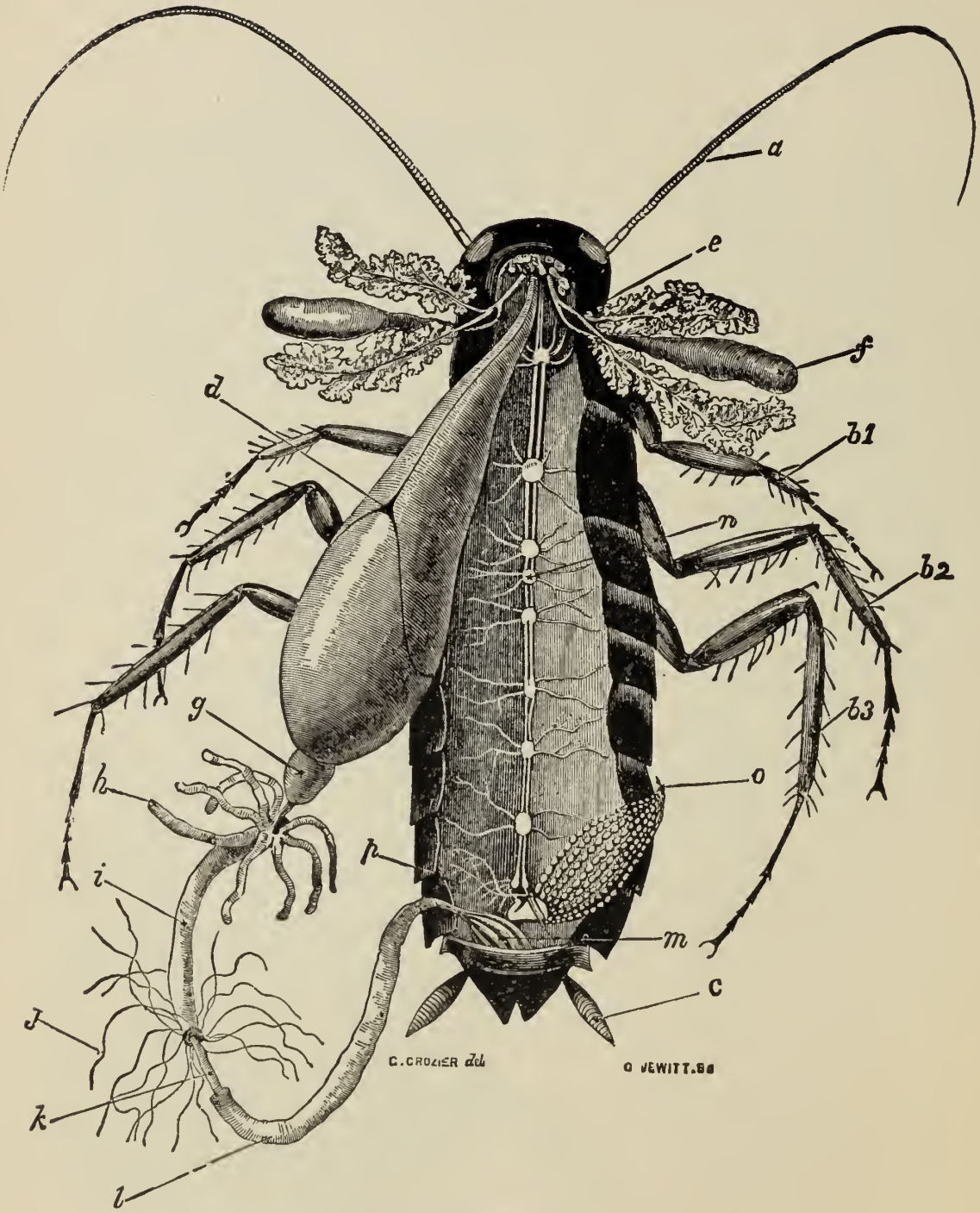
The muscles of insects appear very differently from those (the lean meat) of higher animals. In insects the muscles are either colorless and transparent, or yellowish white; and they are soft, almost of a gelatinous consistence. When hardened by alcohol or otherwise, and examined with a microscope, they are seen to be crossed by numerous transverse lines, like the voluntary muscles of Vertebrates.

As a rule, the muscles of insects are composed of an immense number of distinct fibres, which are not enclosed in tendinous sheaths as with Vertebrates. But the muscles that move the appendages of the body are furnished with a tendon at the end farthest from the body (Fig. 81).

Fig. 81.—Leg of May-beetle. (After Straus-Durckheim.)

Notwithstanding the soft and delicate appearance of the muscles of insects, they are really very strong. One has only to observe the power of leaping possessed by many species to be convinced of this.

PLATE III.



A Cockroach (*Periplaneta orientalis*).

(From Rolleston).

a, antennæ; b_1, b_2, b_3, tibiæ; *c*, anal cerci; *d*, ganglion on recurrent nerve upon the crop; *e*, salivary duct; *f*, salivary bladder; *g*, gizzard; *h*, hepatic cœca; *i*, chylific stomach; *j*, Malpighian vessels; *k*, small intestine; *l*, large intestine; *m*, rectum; *n*, first abdominal ganglion; *o*, ovary; *p*, sebaceous glands.

And the rapidity of their action is even more wonderful than their strength. This rapidity is best illustrated by the muscles that move the wings. Every one has observed gnats and other flies poising in mid air by a movement of the wings so rapid that the eye cannot follow it. Physicists have been able, however, to count these vibrations by determining the pitch of the musical note produced in this way. And they tell us that certain gnats vibrate their wings 15,000 times per second.

The Alimentary Canal.—The typical position of this is represented in the diagram (Fig. 80); and on Plate III, illustrating the anatomy of a cockroach, its form in that insect is shown. In larvæ it is a nearly straight tube, extending from one end of the body to the other. But in adult insects it is usually much longer than the body, and is consequently more or less folded. It is composed of parts differing in form and use. To these parts names have been given similar to those used to designate the corresponding parts in higher animals; thus we distinguish a *pharynx*, an *œsophagus*, sometimes a *crop*, sometimes a *gizzard*, a *stomach*, a *small intestine*, and a *large intestine*.

The Adipose Tissue, or Fat.—On opening the body of an insect, especially of a larva, one of the most conspicuous things to be seen is fatty tissue, in large masses. These often completely surround the alimentary canal, and are held in place by numerous branches of the tracheæ with which they are supplied. Other and smaller masses of this tissue adhere to the inner surface of the abdominal wall, in the vicinity of the nervous system, and at the sides of the body. In a full-grown larva of *Corydalis cornuta* I have found the adipose tissue to be greater in bulk than all of the other organs found inside of the muscular walls of the body. In adult insects it usually exists in much less quantity than in larvæ.

The Blood-vessels.—In insects all parts of the body cavity that are not occupied by the internal organs are filled with blood. Thus the alimentary canal is completely surrounded with blood, and all the spaces between the muscles are filled by this fluid. This is a very different arrangement from what occurs in our own body, where the blood is contained in a system of tubes, the arteries and the veins. We find, however, that insects are not entirely deprived of blood-vessels. For there is one which lies above the alimentary canal, just within the middle line of the back. See Figure 80, *h*, and Plate II, 1. This extends from near the caudal end of the abdomen through the thorax into the head. That part of this system that lies in the abdomen

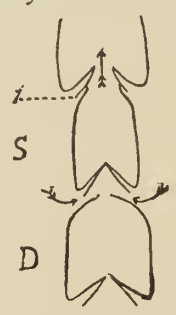


FIG. 82.—Diagram of a part of the heart of a May-beetle.

is usually termed the *heart*. This is a somewhat complicated organ consisting of several chambers arranged in series, and each communicating with the one in front of it by an opening furnished with valves. The number and form of these chambers differ in different insects. Fig. 82 represents the heart of a May-beetle. These chambers not only communicate with each other, but communicate with the body-cavity by means of side openings, which are also furnished with valves. These two sets of valves act in such a way that when a chamber of the heart contracts a stream of blood is forced towards the head, and when it expands the blood rushes into it through the side openings, and from the chamber behind it. Attached to the lower surface of the heart and extending out to the side of the body there is on each side a series of triangular muscles: these have been termed the wings of the heart (Plate II, 6, and Fig. 83, *c*). In Figure *c* they are represented cut away from the caudal part of the heart. The prolongation of the heart, which extends through the thorax and into the head, is termed the *aorta*.

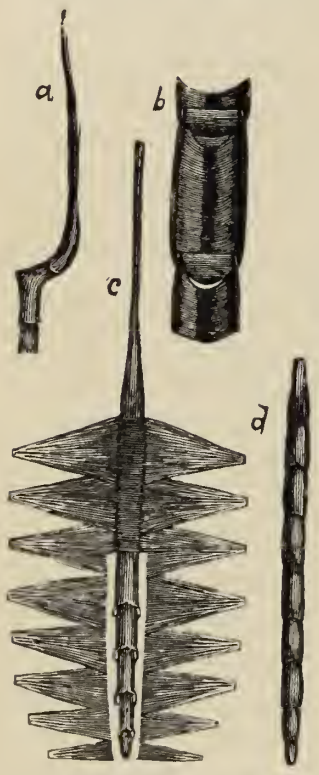


FIG. 83.—Heart of May-beetle (after Straus-Durckheim): *a*, lateral aspect of aorta; *b*, interior of heart showing valves; *c*, ventral aspect of heart and wing-muscles—the muscles are represented as cut away from the caudal part of the heart; *d*, dorsal aspect of heart.

The blood is forced by the heart through the aorta into the head, where it escapes into the body cavity. From this point it flows through the body cavity in regular streams, which have definite directions, but which are not included in vessels. They, like the ocean currents, are definite streams with liquid shores.

The blood is usually colorless, or slightly tinged with green; but its circulation is made conspicuous by the movements of the large corpuscles with which it abounds. In transparent insects it can be seen pouring forth from the cephalic end of the aorta, bathing first the brain, and then passing to all parts of the body, even out into the appendages. By tracing the course of any one of these currents it will be found to flow, sooner or later, to the cavity between the wings of the heart and the back in which the heart rests, and from which it receives its blood.

The Nervous System.—The central part of the nervous system, as

already indicated, consists of a ganglion in the head above the œsophagus, and of a series of ganglia, typically one for each segment of the body, lying on the floor of the body cavity, and connected by two longitudinal cords. In the head, one of these cords passes on each side of the œsophagus, from the brain to another ganglion in the head below the œsophagus, thus forming a nervous collar about the alimentary canal. From each ganglion nerves arise, which supply the adjacent parts; and from the thoracic ganglia nerves extend to the legs and wings. This series of ganglia is really a double one; but each pair of ganglia are more or less closely united on the middle line of the body, and often appear as a single ganglion. Figure 84 gives a general view of the nervous system of *Corydalis cornuta*. From the brain (*a*) two large nerves extend to the compound eyes, and a smaller pair to the antennæ, the sub-œsophageal ganglion (*b*) supplies the mouth-parts with nerves; and each of the thoracic and abdominal ganglia supplies its segment of the body.

FIG. 84.—Nervous system of *Corydalis*. (After Leidy.)

How Insects Breathe—The Respiratory System.—A common mistake made by beginners in the study of Entomology is to suppose that insects breathe through the mouth as do the higher animals. Many a beginner has carefully poured chloroform on the head of an insect in the expectation of killing it in that way, and has been surprised at his poor success.

The truth is, insects breathe through their sides. If an insect be carefully examined, there can be found along the sides of the body a series of openings (Fig. 85). These are the openings through which

FIG. 85.—Side-view of Locust with wings removed.

the air passes into the respiratory system and are termed *spiracles* (spir'a-cles).

The number of spiracles varies greatly in different insects. There is, however, never more than one pair on a single segment of the body. They do not occur on the head, but are borne by each of the thoracic segments, and by the first eight abdominal segments. Thus there are eleven segments that may bear spiracles, but they are always lacking on some one or more of these.

These spiracles are either simple openings into the respiratory system, or are provided with valves, sieves, or fringes of hair for the exclusion of dirt. They lead into a system of air-tubes termed *tracheæ* (tra'che·æ). The accompanying figures will indicate the distribution of the main trunks of these tracheæ in a cockroach (Figs. 86 and

FIG. 86.—Tracheal system of Cockroach. The dorsal integument removed and the alimentary canal in place. (After Miall and Denny.)

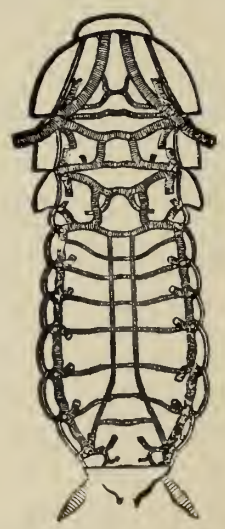


FIG. 87.—Tracheal system of Cockroach. The alimentary canal removed to show the ventral tracheal communications. (After Miall and Denny.)

87). There is a short trunk arising from each spiracle; these are connected together by a large longitudinal trunk on each side of the body, and by numerous transverse trunks. From these large tracheæ there arise a great number of smaller ones, not shown in the figures, which branch and subdivide, and extend to all parts of the body. When one dissects an insect the viscera are found to be connected together by the ramifications of these tracheæ, so that in order to remove any organ it is necessary to cut some of them. The smaller branches of the tracheæ are exceedingly minute, and are intimately associated with the various tissues. By means of these fine tracheal trunks the air is carried to the tissues; hence the blood plays a much smaller part in respiration than it does in the Vertebrates.

Although insects are, strictly speaking, air-breathing animals, many of them, as is well known, live in the water. The study of the ways in which aquatic insects breathe is a very interesting one; it

presents to us many wonderful modifications of structure. Some of the more common of these are described in subsequent pages of this book; in this place we can only make a few generalizations.

The various modes of respiration of aquatic insects may be classified under two heads: first, those in which the insects obtain air from above the surface of the water; second, those in which the insects breathe the air that is mechanically mixed with the water.

With many aquatic insects the spiracles open beneath the wings, which are folded upon the abdomen. The insect, by coming to the surface of the water and lifting the tip of its wings, forms a cavity beneath them, into which the air rushes. The insect can then swim through the water, carrying this air with it in a position where it can be respired. When the air becomes impure, the insect rises to the surface, forces out the air from beneath its wings, and takes in a new supply. Water-beetles and aquatic bugs afford familiar examples of this mode of respiration.

Some insects are provided with long tubes connected with their spiracles, by means of which they can draw their supply of air from above the surface of the water while they crawl upon the bottom of shallow ponds. Our most common illustrations of this are bugs of the family *Nepidæ*; but the most remarkable development of this kind is exhibited by certain Dipterous larvæ of the family *Syrphidæ*, known as Rat-tailed Maggots.

Although there are many insects that live in the water and draw their supply of air from above it, the greater number of aquatic insects breathe, as do fishes, the air that is mixed with the water. This is accomplished by organs known as *tracheal gills*. These are hair-like or more or less plate-like expansions of the body-wall, abundantly supplied with tracheæ (Fig. 88). These tracheæ divide and subdivide, and their terminations or fine branches are separated from the water that bathes the organ only by its thin walls. In this way the air contained in the tracheæ is separated from the air in the water only by a delicate membrane, which admits of the transfer of gases between them. It will be observed that the difference between a tracheal gill and a true gill (as of fishes, crustacea, etc.) is that the true gill is supplied with vessels containing *blood*, which is purified by being brought in contact with the air in the water, while the tracheal gill is supplied with tracheæ containing *air* to be purified.

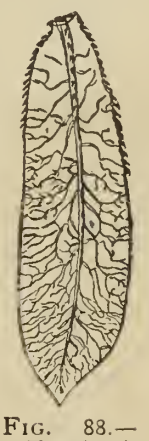


FIG. 88.—Tracheal gill of *Agrion*.

Tracheal gills are usually borne by the abdomen, sometimes by the thorax, and in case of one genus of Stone-flies by the

head. They pertain almost exclusively to the immature stages of insects; but Stone-flies of the genus *Pteronarcys* retain them throughout their existence.

Tracheal gills vary greatly in form; in *Corydalis* they are hair-like, and occur in tufts near the lateral margins of the abdominal segments; in the Caddice-worms they are thread-like, more or less branched, and irregularly distributed over the surface of the abdomen; and in certain Dragon-flies they are in the form of large plate-like caudal appendages. (Fig. 88.)

The Reproductive Organs.—The reproductive organs are situated in the abdomen, as represented in Figure 80. There is a set on each side of the body; but the two sets usually open by a common tube near the caudal end of the body. In the May-flies and in the Ear-wigs, however, the reproductive organs of each side have a distinct opening. Thus May-flies are often found with two bunches of eggs projecting from the caudal end of the body.

All insects are developed from eggs; but there are some apparent exceptions. Thus many flies retain their eggs until after they are hatched, if a proper place for laying them is not found earlier; and in some flies (the *Pupipara*) the young attain a considerable development before they are born. In the Plant-lice (*Aphididæ*) there is a remarkable alternation of reproduction by budding with the sexual reproduction. This is described more fully in the account of that family.

The Orders of the Hexapoda.

(*For advanced students.*)

The Class Hexapoda, or Insects, is divided in this work into nineteen orders. This number is somewhat greater than what has been commonly adopted heretofore. But we believe that in the earlier classifications forms were brought together in the same order that are not closely related, and that consequently the present classification represents better the true relationship of the groups of insects.

There has been some hesitation on the part of many entomologists in adopting this division of certain of the old orders, merely for the reason that they felt that the old classification was simpler. But we do not share in this feeling. It seems to us that it is easier for the student to learn the characters of a large number of well-defined groups than it is to learn those of a smaller number of vaguely-defined groups.

In arranging the orders in a linear series, as must be done in a book, it is impossible to indicate in a satisfactory way either the relation of the orders to each other or the relative rank of the orders. An effort is made to place near together closely allied orders, and to treat first those that are more simple or primitive or generalized in structure, and last those that are more specialized. But this plan could be fully carried out only by having several parallel columns on the pages of the book, each representing a distinct line of descent, an arrangement which, to say the least, is impracticable.

What has been done in this work is to place first the *Thysanura*, which is doubtless the most primitive order. Then follow first the orders that undergo an incomplete metamorphosis, and last, those that undergo a complete metamorphosis. Within these two groups of orders those with biting mouth-parts are placed first, and these are followed by those with sucking mouth-parts, except that in the second group the Coleoptera and Hymenoptera are placed last for want of a better position. We do not intend to indicate by this that these two orders are closely related, or that they are more specialized than the Diptera.

In fact, with regard to at least five of the orders of insects (Hemiptera, Lepidoptera, Diptera, Coleoptera, and Hymenoptera), it seems idle to us to discuss which is the more highly specialized. Each has been specialized in a direction peculiar to itself ; and to attempt to describe which is the "highest" seems as futile as the discussion by children of the question : "Which is better, sugar or salt?"

We give below a table for use in classifying specimens. This table is merely intended to aid the student in determining to which of the orders a specimen that he is examining belongs. No effort has been made to indicate in the table the relation of the orders to each other.

TABLE FOR DETERMINING THE ORDERS OF HEXAPODA.*

(*This table includes only adult insects.*)

A. Wingless or with rudimentary wings.

B. Mandibles and maxillæ retracted within the cavity of the head so that only their apices are visible. p. 82 ..... THYSANURA.

BB. Mandibles and maxillæ more or less prominent and fitted for biting. (See BBB also.)

C. Head with long, trunk-like beak. (*Boreus.*) p. 184. MECOPTERA.

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* See note at bottom of p. 10.

CC. Head not prolonged into a trunk.

D. Louse-like insects of small size; body less than one-sixth inch in length.

E. Antennæ with not more than five segments. (Bird-lice.) p. 100 ..... MALLOPHAGA.

EE. Antennæ with many segments. (Book-lice.) p. 98. CORRODENTIA.

DD. Insects of various forms, but not louse-like, and, except in the case of some ants, with the body more than one-sixth inch in length.

E. Abdomen with short, conical, compressed, many-jointed caudal appendages. (*Cockroaches.*) p. 104...ORTHOPTERA.

EE. Abdomen without jointed caudal appendages.

F. Legs fitted for jumping. (*Wingless Locusts, Grasshoppers, and Crickets.*) p. 104 ..... ORTHOPTERA.

FF. Legs fitted for running.

G. Abdomen broadly joined to thorax.

H. Body linear. (*Walking-sticks.*) p. 104. ORTHOPTERA.

HH. Body white and somewhat ant-like in form. (*Termes.*) p. 95.....ISOPTERA.

HHH. Body neither linear nor ant-like in form. (*Wingless Fire-fly et al.*) p. 494.....COLEOPTERA.

GG. Base of abdomen strongly constricted. (*Ants et al.*) p. 599 ..... HYMENOPTERA.

BBB. Mouth-parts formed for sucking.

C. Small abnormal insects in which the body is either scale-like or gall-like in form, or grub-like and clothed with wax. The waxy covering may be in the form of powder, of large tufts or plates, of a continuous layer, or of a thin scale, beneath which the insect lives. (*Coccidæ.*) p. 121.....HEMIPTERA.

CC. Body more or less covered with minute scales, or with thick long hairs. Prothorax not free (*i.e.*, closely united with the mesothorax). Mouth-parts usually consisting of a long "tongue" rolled beneath the head. p. 191.....LEPIDOPTERA.

CCC. Body naked, or with isolated or bristle-like hairs.

D. Prothorax not well developed, inconspicuous or invisible from above. Tarsi five-jointed. Mouth-parts developed into an unjointed trunk; palpi present. p. 413....DIPTERA.

DD. Prothorax well developed.

E. Body strongly compressed; tarsi five-jointed. (*Fleas.*) p. 490.....SIPHONAPTERA.

EE. Body not compressed; tarsi one-, two, or three-jointed.
F. Last joint of tarsi bladder-like or hoof-like in form and without claws; mouth-parts forming a triangular, unjointed beak; palpi present. p. 119.....PHYSOPODA.
FF. Last joint of tarsi not bladder-like, and furnished with one or two claws; mouth-parts forming a slender, usually jointed beak; palpi apparently wanting. p. 121.
HEMIPTERA.

AA. Winged. (The wing-covers, *elytra*, of beetles and of earwigs are counted as wings in this table.)
B. With two wings.
C. Wings horny, leathery, or parchment-like.
D. Mouth-parts formed for sucking. Wings leathery, shortened, or membranous at the tip. p. 121.....HEMIPTERA.
DD. Mouth-parts formed for biting. Jaws distinct.
E. Wings horny, without veins. Hind legs not fitted for jumping, p. 494.....COLEOPTERA.
EE. Wings parchment-like, with a network of veins. Hind legs fitted for jumping. p. 104.....ORTHOPTERA.
CC. Wings membranous.
D. Abdomen with caudal filaments. Mouth-parts rudimentary.
E. Halteres wanting. p. 86.....EPHEMERIDA.
EE. Halteres present (males of *Coccidæ*). p. 121. HEMIPTERA.
DD. Abdomen without caudal filaments. Halteres in place of second wings. Mouth-parts formed for sucking. p. 413.
DIPTERA.

BB. With four wings.
C. The two pairs of wings unlike in structure.
D. Front wings leathery at base, and membranous at tip, often overlapping. Mouth-parts formed for sucking. p. 121.
HEMIPTERA.
DD. Front wings of same texture throughout.
E. Front wings horny or leathery, being veinless wing-covers. (*Elytra*.)
F. Abdomen with caudal appendages in form of movable forceps. p. 102.....EUPLEXOPTERA.
FF. Abdomen without forcep-like appendages. p. 494
COLEOPTERA.
EE. Front wings leathery or parchment-like, with a network of veins.
F. Under wings not folded. Mouth-parts formed for sucking. p. 121.....HEMIPTERA.

FF. Under wings folded lengthwise. Mouth-parts formed for biting. p. 104. ..... ORTHOPTERA.

CC. The two pairs of wings similar, membranous.

D. Last joint of tarsi bladder-like or hoof-like in form and without claws. p. 119. .... .PHYSOPODA.

DD. Last joint of tarsi not bladder-like.

E. Wings entirely or for the greater part clothed with scales. Mouth-parts formed for sucking. p. 191... LEPIDOPTERA.

EE. Wings naked, transparent, or thinly clothed with hairs.

F. Mouth-parts arising from the hinder part of the lower surface of the head, and consisting of bristle-like organs inclosed in a jointed sheath. (*Homoptera.*) p. 121. HEMIPTERA.

FF. Mouth-parts in normal position. Mandibles not bristle-like.

G. Wings net-veined, with many veins and cross-veins.

H. Tarsi consisting of less than five segments.

I. Antennæ inconspicuous, awl-shaped, short and slender.

J. First and second pairs of wings nearly the same length ; tarsi three-jointed. p. 89. ODONATA.

JJ. Second pair of wings either small or wanting ; tarsi four-jointed. p. 86. ..... .EPHEMERIDA

II. Antennæ usually conspicuous, setiform, filiform clavate, capitate, or pectinate.

J. Tarsi two- or three-jointed.

K. Second pair of wings the smaller. p. 98. CORRODENTIA.

KK. Second pair of wings broader, or at least of the same size as the first pair. p. 93. PLECOPTERA.

JJ. Tarsi four-jointed ; wings equal. p. 95. ISOPTERA.

HH. Tarsi consisting of five segments.

I. Abdomen with setiform, many-jointed anal filaments. (*Certain May-flies.*) p. 86. EPHEMERIDA.

II. Abdomen without many-jointed anal filaments.

J. Head prolonged into a trunk-like beak. p. 184. ..... MECOPTERA.

J. Head not prolonged into a beak. p. 175. NEUROPTERA.

GG. Wings with branching veins and comparatively few cross-veins, or veinless.

H. Tarsi two- or three-jointed.

I. Posterior wings smaller than the anterior. p. 98. ....CORRODENTIA.

II. Posterior wings as large as or larger than the anterior ones. (*Certain Stone-flies.*) p. 93. PLECOPTERA.

HH. Tarsi four- or five-jointed.

I. Abdomen with setiform, many-jointed anal filaments. (*Certain May-flies.*) p. 86. EPHEMERIDA.

II. Abdomen without many-jointed anal filaments.

J. Prothorax horny. First wings larger than the second, naked or imperceptibly hairy. Second wings without, or with few, unusually simple, veins. Jaws (mandibles) well developed. Palpi small. p. 599.....HYMENOPTERA.

JJ. Prothorax membranous or, at the most, parchment-like. Second wings as large as or larger than the first, folded lengthwise, with many branching veins. First wings naked or thinly clothed with hair. Jaws (mandibles) inconspicuous. Palpi long. Moth-like insects. p. 186 ..... TRICHOPTERA.

LIST OF ORDERS OF THE HEXAPODA.

THYSANURA.	HEMIPTERA.
EPHEMERIDA.	NEUROPTERA.
ODONATA.	MECOPTERA.
PLECOPTERA.	TRICHOPTERA.
ISOPTERA.	LEPIDOPTERA.
CORRODENTIA.	DIPTERA.
MALLOPHAGA.	SIPHONAPTERA.
EUPLEXOPTERA	COLEOPTERA.
ORTHOPTERA.	HYMENOPTERA.
PHYSOPODA.	

CHAPTER IV.

Order THYSANURA (Thys-a-nu'ra).

Bristle-tails, Spring-tails, Fish-moths, and others.

The members of this order are wingless insects which undergo no metamorphosis, the larval form being retained by the adult. The mandibles and maxillæ are retracted within the cavity of the head, so that only their tips are visible; they have, however, some freedom of motion, and can be used for biting and chewing soft substances. True compound eyes are rarely present; but in some genera there is a group of simple eyes on each side of the head. The abdomen is sometimes furnished with rudimentary legs.

Under stones and decayed leaves and wood, in the chinks of bark, among moss, in damp places, on snow or on pools, or sometimes in houses, are the members of this order to be found. They are for the most part very small insects, but sometimes they are numerous and lively enough to make up for their lack in size. They have no wings, but they can either run very fast or jump very far. Their mouth-parts are usually fitted for biting, but are very difficult to study, because they are retracted within the

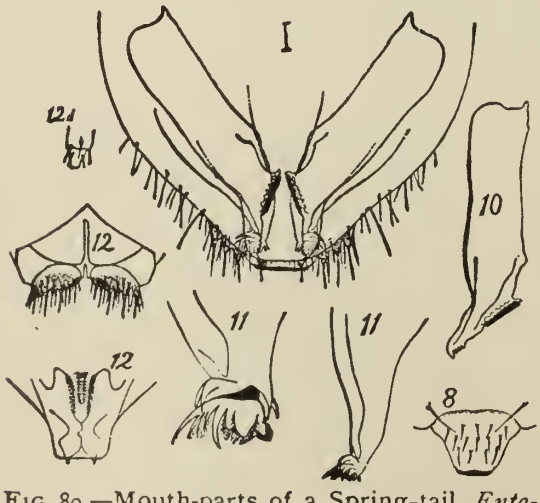

FIG. 89.—Mouth-parts of a Spring-tail, *Entomobryidæ*. (Drawn by J. M. Stedman, under the author's direction.) 8, labrum; 10, mandible; 11, maxilla; 12, labium; 12*d*, labial palpus.

cavity of the head, and also on account of the small size of the insects. Figure 89 represents them in place in the head, and also each separately.

In certain respects these insects represent a connecting-link between the other six-footed insects (Hexapoda) and the Myriapods; for many of the Thysanura have rudiments of legs on the abdomen. It is believed, therefore, that they are much like the first insects that appeared on the earth in ancient geological times.

The Thysanura undergo no metamorphosis, the young resembling the adult in form.

The name of the order is from two Greek words: *thysanos*, a tassel; and *oura*, the tail.

The Thysanura include two distinct types of insects; these are classed as suborders, and can be distinguished by the following table:

TABLE OF THE SUBORDERS OF THE THYSANURA.

A. With bristle-like and many-jointed appendages at the caudal end of the body (in a single genus these appendages are in the form of forceps, Fig. 91), and without a sucker on the ventral side of the abdomen. p. 83..... .....CINURA.

AA. With a forked sucker on the ventral side of the first abdominal segment. Abdomen with a springing apparatus near its caudal end, or without appendages. p. 84.....COLLEMBOLA.

Suborder CINURA (Ci-nu'ra).

The Bristle-tails.

Often the careful housekeeper sees in the ironing-basket, or upon the book-shelf where she is dusting, a flash of light like a tiny thread of quicksilver, that usually vanishes as soon as seen.

If she is experienced she knows that this streak of light is a little animal, half an inch long, whose body is clothed in shining scales like those of a fish. Hence she calls it a Fish-moth. Its scientific name is *Lepisma saccharina;* (Le-pis'ma sac-cha-ri'na); it is especially abundant in warm climates,

and often does damage to starched clothing, book-bindings, and sometimes loosens wall-paper by eating out the paste. Under a microscope the Fish-moth shows beautiful markings

FIG. 90.—*Lepisma saccharina.* (After Lubbock.)

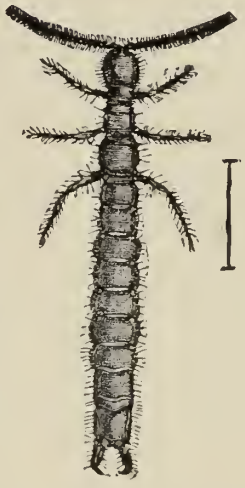

FIG. 91.—*Japyx solifugus.* (After Lubbock.)

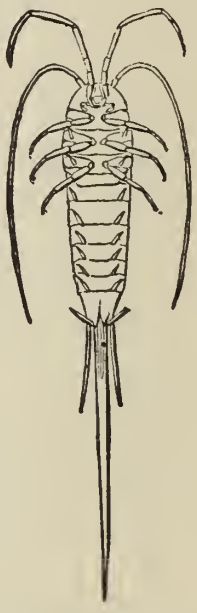

FIG. 92.—Ventral aspect of *Machilis*, showing appendages.

on the shining scales; and at the caudal end of the body are three long bristle-like appendages (Fig. 90), which suggest the common name Bristle-tail applied to members of this suborder. Figure 91 represents *Japyx* (Ja′pyx), a Bristle-tail in which the caudal appendages are in the form of horny forceps; and Figure 92 represents the lower side of *Machilis* (Mach′i-lis), another Bristle-tail, found under stones and loose bark; this genus has rudimentary abdominal legs as shown in the figure.

Suborder COLLEMBOLA (Col-lem′bo-la).

The Spring-tails.

In the Spring in the Northern States, on bright sunny days when it is thawing, one often sees upon the snow thousands of tiny dark specks. In other places pools of still

water appear to be covered by a moving mass of minute grains which become more active when disturbed. These masses as well as the dark specks on snow consist of thousands of little creatures that are provided with a wonderful means of jumping. There is on the end of the body a tail-like organ that is bent under when the insect is at rest, and that reaches almost to the head; this when suddenly straightened throws the insect high in the air and several feet away. This action is like a spring-board jump, only these little fellows always carry their spring-boards with them, and have thus won the name of Spring-tails. The species upon snow, called the Snow-flea, *Achorutes nivicola* (Ach-o-ru'tes ni-vic'o-la), sometimes proves a nuisance in maple sugar-bushes by getting into the sap. Through a microscope a Spring-tail appears very absurd, it has long antennæ and large, dark eye-spots on the face, which, together with the long hair that sticks forward on the head and thorax, give the creature a look of solemn fierceness. Different species may be found at almost any time of the year in damp places. Figure 93 represents one of these. In many forms the body is much more slender than in that figured

FIG. 93.—*Papirius fuscus.* (After Lubbock)

CHAPTER V.

Order EPHEMERIDA (Eph-e-mer'i-da).

The May-flies.

The members of this order have delicate membranous wings, with a fine network of veins; the fore wings are large, and the hind wings are much smaller or wanting. The mouth-parts are rudimentary. The metamorphosis is incomplete.

FIG. 94.—May-fly.

The name of this order is from the Greek word *ephemeros*, lasting but a day. It was given to these insects on account of the shortness of their lives after reaching the adult state.* The May-flies are easily distinguished from other net-winged insects by the peculiar shape of the wings and the relative sizes of the two pairs (Fig. 94).

The mouth-parts are nearly wanting, as these insects eat nothing in the adult state; the antennæ are very small; the abdomen is long, soft, and terminated by two or three many-jointed, thread-like appendages. In their metamorphoses these insects differ from all others in molting once after they have acquired wings fitted for flight.

This order includes only a single family.

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* We have not adopted the name *Plectoptera*, which has been proposed for these insects, on account of its similarity to *Plecoptera*.

Family EPHEMERIDÆ (Eph-e-mer'i-dæ).

The May-flies.

In river or lake towns, during the warm evenings of late spring or early summer, the electric lights or street lamps are often darkened by myriads of insects that dash against them, and the pavements are made slippery by their dead bodies which have been trampled under foot. They are not the ordinary night-flying moths: if an individual of the thousands that cling to the posts and buildings in the vicinity of the light be examined, it will prove to be a delicate creature with dainty, trembling wings and two or three long, white, thread-like organs on the end of its body; the body itself is so transparent that the blood within can be seen pulsating. The front wings are large and finely netted, and the hind wings are small or absent (Figs. 94, 95). So fragile are these pale beings that they seem like phantoms rather than real insects. No wonder that poets have sung of them as the creatures that live only a day. It is true that their winged existence lasts often only a day or even a few hours; but they have another life, of which the poet knows nothing. Down on the bottom of a stream, feeding on mud, water-plants, or other small insects, lives a little nymph with delicate, fringed gills along its sides and two or three long, many-jointed, and often feathery appendages on the end of the body (Fig. 96). It has strong legs and can both walk and swim. After about the ninth molt—there may be twenty molts in all—there appear on its thorax four little sacs which are the beginnings of wings; with each molt these grow larger, until finally the last skin of the water-nymph is shed, and gills and mouth-parts are all left behind, and the insect comes forth, a winged May-fly. But there is still another change to be undergone. The insect has not yet reached the adult state. After flying a

FIG. 95.—*Cænis*, a two-winged May-fly.

FIG. 96.—Nymph of May-fly.

short distance it alights and sheds its skin again, a thin layer coming off from all parts of its body, even from its wings. After this the delicate creature is more fragile than before. It now has but one duty to perform in its brief life in the air, and that is to lay its eggs. These are sometimes laid on the surface of the water, and sometimes the mother wraps her wings about her like a diving-bell and goes down into the water and deposits her eggs on stones. The life of the nymph is from one to three years, according to the species.

CHAPTER VI.

Order ODONATA (Od-o-na'ta).

The Dragon-flies.

The members of this order have four membranous wings, which are finely netted with veins; the hind wings are as large or larger than the fore wings; and each wing has near the middle of the front margin a joint-like structure, the nodus. The mouth-parts are formed for biting. The metamorphosis is incomplete.

The name of this order is evidently from the Greek word *odous*, a tooth; but the reason for applying it to these insects is obscure.

FIG. 97.—*Libellula basalis.*

The Odonata are easily recognized by the form of their wings, which are long, narrow, and powerful; and, possess near the middle of the front margin of each a little notch

and a strong cross-vein. This structure resembles in appearance a joint, and is consequently named the *nodus*.

The mouth-parts are fitted for biting, these insects being voracious feeders in the adult state. Both the upper lip and the lower lip are large, and the two nearly enclose the jaws

FIG. 98.—*Agrion.*

FIG. 99.—Nymph of Dragon-fly, *Agrioninæ*.

when at rest. There are two distinct types of Dragon-flies: in one the wings are extended horizontally when at rest (Fig. 97); in the other the wings are folded together above the abdomen when not in use (Fig. 98).

This order includes only a single family.

Family LIBELLULIDÆ (Lib-el-lu'li-dæ)

The Dragon-flies.

Darning-needles, Devil's-needles, Snake-doctors, Spindles, and Dragon-flies are some of the names given to those insects which dart back and forth over streams and wet places,

their rapidly moving wings throwing out gleams of metallic color as they go. Still more beautiful are they when at rest, their wings wide-spread or folded together above the abdomen, and as rigid and motionless as if made of iridescent glass; and their great compound eyes shining like gold or precious stones. But for all their terrible names Dragon-flies are entirely innocent of any harm to mankind. They neither sew up people's ears, as northern children think; nor bring dead snakes to life, as colored people in the South believe; but they are very fierce enemies to their insect kindred. Their long, narrow, closely netted wings are strong, carrying them swiftly; and their jaws are powerful, and their appetites good; so it is an unfortunate insect that falls in their way.

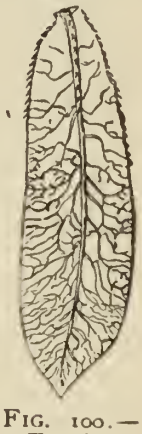

FIG. 100.—Tracheal gill of *Agrion.*

The mother Dragon-fly lays her eggs in water or fastens them to aquatic plants. The young as soon as hatched swim off and hunt for some smaller creatures to eat. They have strong legs and big jaws, and are real insect ogres. The lower lip when extended reaches far out, and is armed with powerful hooks with which to grab their prey; but when folded up it is so large that it is called a mask and gives the insect's face a comical resemblance to that of a bull-dog. These nymphs have a peculiar method of breathing. The caudal end of the alimentary canal is lined with tracheæ. The insect alternately draws water into this cavity and expels it; and thus the air in these tracheæ is purified, this part of the alimentary canal acting as a tracheal gill. This process also helps the insect in swimming, for the water may be expelled with such force that the whole body is sent forward. In some species the nymphs have also two or three large

FIG. 101.—Exuviæ of nymph of Dragon-fly.

plate-like gills on the end of the abdomen (Fig. 99). Figure 100 represents one of these gills enlarged. When the nymph get its growth it crawls out of the water and rests on some grass-blade or reed; then the skin splits down the back and the Dragon-fly comes forth, while the old skin, perfect in form, still clings to its resting-place like a ghost until some inquiring wind blows it away (Fig. 101).

CHAPTER VII.

Order PLECOPTERA (Ple-cop'te-ra).

The Stone-flies.

The members of this order have four membranous wings, with comparatively few or with many cross-veins; the hind wings are much larger than the fore wings, and are folded in plaits and lie upon the abdomen when at rest. The mouth-parts are of the biting type of structure, but are frequently poorly developed. The metamorphosis is incomplete.

The name of this order is from two Greek words: *plecos*, plaited; and *pteron*, a wing. It refers to the way in which the hind wings are folded when at rest.

Although the mouth-parts are of the biting type of structure, the mandibles are often small, flat, and membranous, and evidently of little use. It is probable that as a rule the adults eat but little. The antennæ are long, tapering, and many-jointed; and in most species the caudal end of the abdomen is furnished with two many-jointed bristles. The nymphs are aquatic.

This order includes only a single family.

Family PERLIDÆ (Per'li dæ).

The Stone-flies.

Those boys fond of fishing know that a good place to find bait is under stones in streams. And doubtless they have often observed that in the swiftest portion of the stream the turned-over stones have clinging to the lower surface

flat creatures from one-half inch or less to one and one half inches in length. They cling so closely and are so nearly the color of the stone that they look almost like fossils. Their antennæ and caudal bristles and three legs on each side extend out like the rays of a star; the six soft clumps of white hair-like gills, one behind each leg, alone show that they are not engraved upon the stone (Fig. 102). These insects are the nymphs of the stone-flies, and are the favorite food of fishes, especially of brook trout. If a nymph is fortunate enough to escape the fate of being a luncheon for fish, when it is full-grown it crawls forth from the water and

FIG. 102.—Nymph of Stone-fly, *Acroneura*.

FIG. 103.—*Pteronarcys regalis*.

transforms to a gray or greenish fly, with slender, closely veined fore wings and wide, delicate hind wings (Fig. 103). The cast nymph-skins are common objects on the banks of the streams which these insects inhabit. Several of the smaller species of the stone-flies appear in the winged state upon snow in early spring, and often find their way into houses.

CHAPTER VIII.

Order ISOPTERA (I-sop'te-ra).

The Termites or White-ants.

The members of this order are social insects. Each species consists of several distinct castes, of which only the "Kings" and the "Queens" are winged. These have four long, narrow wings, which are somewhat leathery in structure, and which are furnished with numerous but more or less indistinct veins. The two pairs of wings are similar in form and structure, and are laid flat upon the back when not in use. The mouth-parts are formed for biting. The metamorphosis is incomplete.

The name of this order is from two Greek words: *isos*, equal; and *pteron*, a wing. It refers to the fact that the two pairs of wings are similar in form and structure.

The wings of the Termites (Ter'mites), although really broad when compared to the size of the body, appear narrow on account of their great length, being in many cases more than twice as long as the entire body.

The order includes only a single family.

Family TERMITIDÆ (Ter-mit'i-dæ).

The Termites or White-ants.

These interesting insects are not Ants, nor at all related to them; but they have been thus called because they have certain social habits that are similar to those of true Ants. They are more abundant in the tropics than here; and

there build nests or mounds sometimes twelve feet high, or make roundish nests several feet thick on trees. Our Northern species (*Termes flavipes*) lives in old logs and stumps, or under stones in the ground.

A remarkable thing about the White-ants is the way they are divided into classes, each class fitted to do a certain work for the colony. First, there is the class of *workers* (Fig. 104), which is constituted of both sexes: they are wingless, and of a dirty-white color, and while they resemble true ants somewhat, their waists are thicker. Their business is to bring food for everybody, feed and bring up the young termites, and build nests. Second, there is the class called *soldiers* (Fig. 105): these too are of both sexes and wingless, and look somewhat like the workers, only their heads are tremendous in size, being often nearly as long as the rest of the body, and their jaws are large and powerful. Third, is the royal class called *kings* and *queens*. It would have been better to have called them fathers and mothers, as they are the parents of the colony, and do not rule it. This class when grown have wings which lie flat upon the back when at rest, and may be twice as long as the body. In May or June in our common species this class swarms forth from all the nests of the neighborhood. After a flight of some distance the wings are shed, and a king chooses some queen near him and proposes that they start a kingdom of their own. But like mortal kings and queens they cannot reign unless a kingdom is found for them, and so millions of these royal pairs die because they have no subjects. But sometimes a fortunate couple is discovered by some termite workers, who at once take possession of the

FIG. 104.—*Termes flapives*, worker.

FIG. 105.—*Termes flavipes*, soldier.

wanderers and provide them with food, and with shelter in the shape of a large circular shallow cell. In this they are really imprisoned, but are well cared for. Soon the queen or mother begins to develop eggs, and her body grows enormously. Finally, it is nothing but a huge sac filled with eggs, looking more like a potato than anything else, and is sometimes six or seven inches long (Fig. 106). Of course the poor queen cannot move herself in the least, and if she were not fed would soon starve; but her king remains devoted to her, and her ladies and gentlemen in waiting do their best to make her comfortable: they carry away the eggs to other chambers as soon as they are laid, then care for the eggs, and feed the little ones when they are hatched. The young termites are active, and resemble the adult in form. If a nest becomes queenless, and the workers are unable to procure a queen, there are developed in the nest wingless sexual individuals, which are termed complemental males and females. But as each complemental female lays only a few eggs, it requires several to take the place of a real queen.

FIG. 106.—Queen white-ant, *Termes gilvus*.

All White-ants are miners, and avoid the light. They build covered-ways wherever they wish to go. In hot countries they are a terrible pest, as they feed upon wood, and actually destroy buildings and furniture and libraries. They leave merely the outside portion of what they feed upon; and they have been known to enter a table through the bottom of the legs and to eat all the inner portions so that a slight weight crushed it to the floor. In Florida they do damage to orange and other trees by girdling them below the surface of the ground.

CHAPTER IX.

Order CORRODENTIA (Cor-ro-den'ti-a).

The Psocids (Psoc'ids) and the Book-lice.

The winged members of this order have four membranous wings, with the veins prominent, but with comparatively few cross veins; the fore wings are larger than the hind wings; and both pairs when not in use are placed roof-like over the body, being almost vertical, and not folded in plaits. The mouth-parts are formed for biting. The metamorphosis is incomplete.

FIG. 107.—*Psocus venosus.*

The name of this order is from the Latin *corrodere*, to gnaw, and refers to the gnawing habits of these insects.

The wings, especially the fore wings, are often smoky in color or variegated. The arrangement of the veins of the wings (Fig. 107) differs in a striking manner from that of any other biting insect.

The order includes two families, but representatives of only one of them occur in the United States.

Family PSOCIDÆ (Psoc'i-dæ).

The Psocids (Pso'cids) and the Book-lice.

Books may be old and out of date from our standpoint, but still be of vital importance to others. Take down from the shelf a time-yellowed book and open its neglected leaves

and watch the pale tiny creatures that scurry across its pages; examine one of them with a lens, look well at his alert, knowing, black eyes, and we are sure you will believe that he is in search of real literature, and not merely a feeder upon paper, as we are taught. Anyway, scientists have concluded that these insects look wise enough to bear the name *Atropos divinatoria* (At'ro-pos di-vin-a-to'ri-a), or the Divining Atropos (Fig. 108). They are, however, more commonly called simply book-lice.

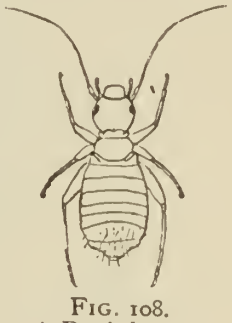

FIG. 108.
A Book-louse.

Some members of the family Psocidæ do not live in books, but feed upon lichens that are found on the trunks of trees and on fences, often a great number being grouped together. Many of these have wings, and look like plant-lice (Fig. 107). The eggs are laid in heaps on leaves and branches, and are covered with a tissue of threads; for the Psocids have the power of spinning silk similar to that spun by spiders.

CHAPTER X.

Order MALLOPHAGA (Mal-loph'a-ga).

The Bird-lice.

The members of this order are wingless parasitic insects, with biting mouth-parts. Their metamorphosis is incomplete.

The name of the order is from two Greek words: *mallos*, wool; and *phagein*, to eat. Although some species infest sheep and goats, feeding upon their wool, by far the greater number live among the feathers of birds. It is due to this fact that the common name Bird-lice is applied to the entire group.

The order includes several families; but we will not take the space to define them.

The Bird-lice are well known to most people that have pet birds or who keep poultry. They differ from the true Lice in having biting mouth-parts, and in feeding upon either feathers, hair, or the skin; while the true Lice have sucking mouth-parts and feed upon blood.

It is to free themselves from these pests that hens wallow in the dust. When poultry are kept in closed houses they should be provided with a "dust-bath." All poultry-houses should be cleaned at least twice a year, and the old straw burned. Sprinkling powdered sulphur in the nests and oiling the perches with kerosene will tend to keep the pests in check. If a poultry-house becomes badly infested, it should be cleaned thoroughly, and every part whitewashed; and the poultry should be dusted with Buhach or Persian insect powder (*Pyrethrum*).

Fig. 109 represents *Goniodes stylifer* (Gon-i-o′des styl′i-fer), a species which infests the turkey; and Fig. 110,

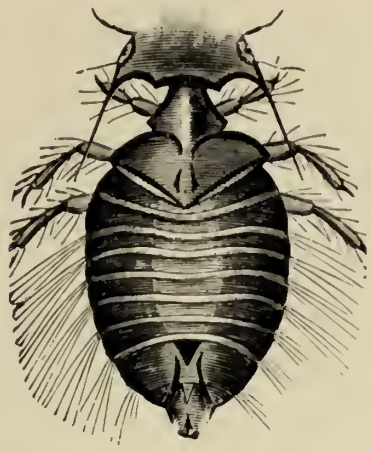

FIG. 109.—*Goniodes stylifer.* (From Law.)

FIG. 110.—*Trichodectes scalaris.* (From Law.)

Trichodectes scalaris (Trich-o-dec′tes sca-la′ris), a species infesting the ox.

CHAPTER XI.

Order EUPLEXOPTERA (Eu-plex-op'te-ra).

The Earwigs.

The members of this order have apparently four wings; the first pair of which are leathery, very small, without veins, and when at rest meet in a straight line on the back; the second pair are large, with radiating veins, and when at rest are folded both lengthwise and crosswise. The mouth-parts are formed for biting. The caudal end of the body is furnished with a pair of appendages which resemble forceps. The metamorphosis is incomplete.

The name of the order is from three Greek words: *eu*, well; *pleko*, to fold; and *pteron*, wing. The word is not well formed, but it cannot now be changed. It refers to the unusual folding of the hind wings. This order is termed the Dermaptera by many entomologists, but this name was first applied to certain other insects, and so should not be used for these. The so-called fore wings of these insects resemble the wing-covers of beetles, and probably like them are not true wings. The hind wings are very different from those of any other insects. Figure 111 represents one of these; they are furnished with radiating veins, which extends from a point some distance from the base of the wings. When the wing is not in use that part over which these veins extend is folded in plaits like a fan, after which the wing is folded twice crosswise. Al-

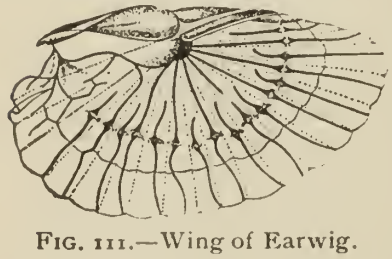

FIG. 111.—Wing of Earwig.

though these insects bear some resemblance to beetles, they differ from them markedly in having an incomplete metamorphosis. The order includes only a single family.

Family FORFICULIDÆ (For-fi-cu'li-dæ).

The Earwigs.

These are long and narrow insects, resembling rove-beetles in the form of the body and in the shortness of the wing-covers, but easily distinguished by having a pair of forceps at the end of the body (Fig. 112). The common name, earwig, has reference to a widely spread fancy that these insects creep into the ears of sleeping persons.

FIG. 112.—An Earwig.

The earwigs are rare in the North-eastern United States, but are more often found in the South and on the Pacific coast. In Europe they are common, and are often troublesome pests, feeding upon the corollas of flowers, fruits, and other vegetable substances.

CHAPTER XII.

Order ORTHOPTERA (*Or·thop'te-ra*).

Cockroaches, Crickets, Grasshoppers, and others.

The members of this order have four wings: the first pair are thickened, and overlap when at rest; the second pair are thinner, and are folded in plaits like a fan. The mouth-parts are formed for biting. The metamorphosis is incomplete.

The order Orthoptera includes some of the very common and best-known insects. The most familiar representatives are those named above.

Although the song of the Katydid and the chirp of crickets are most often associated with recollections of pleasant evenings spent in the country, we cannot forget that to members of this order are due some of the most terrible insect scourges man has known. The devastations caused by great swarms of migratory locusts are not only matters of historical record, but are too painfully known to many of our own generation in the Western States.

With the exception of a single family (*Mantidæ*), the members of this order are, as a rule, injurious to vegetation; and many species are quite apt to multiply to such an extent that their destruction of vegetation becomes serious.

The name of the order is from two Greek words: *orthos*, straight; and *pteron*, a wing. It refers to the longitudinal folding of the hind wings.

In the Orthoptera the two pairs of wings differ in structure. The fore wings are parchment-like, forming covers for the more delicate hind wings. These wing-covers have re-

ceived the special name *tegmina* (teg'mi-na); they are furnished with a fine network of veins, and overlap at the tip at least. There are many species in which the wings are rudimentary, even in the adult state. Such adults resemble nymphs; but in the case of the jumping Orthoptera, where this peculiarity most often occurs, nymphs can be distinguished by the fact that the rudimentary hind wings are outside of the fore wings, instead of beneath them, as in the adult state.

This order includes only six families. We are able, therefore, to discuss all of them in this work. The following synopsis will aid the student in fixing in his mind the more important characteristics of each family.

SYNOPSIS OF THE FAMILIES OF THE ORTHOPTERA.

THE RUNNING ORTHOPTERA.—The body is oval when seen from above, and is very flat; the three pairs of legs are similar in form; the insects run rapidly. p. 106.....BLATTIDÆ.

THE GRASPING ORTHOPTERA.—The prothorax is very long and slender; the first pair of legs are very different from the others, and are fitted for grasping. p. 106.....MANTIDÆ.

THE WALKING ORTHOPTERA.—The body is very long and slender; the three pairs of legs are similar in form, and are also very long and slender; the insects walk slowly. p. 108....PHASMIDÆ.

THE JUMPING ORTHOPTERA.—The hind legs are very much stouter or very much longer, or both stouter and longer, than the middle pair, being fitted for jumping. This group includes three families:

The Short-horned Grasshoppers, or Locusts.—The antennæ are shorter than the body. The ovipositor of the female is short and composed of four separate plates. The tarsi are three-jointed. p. 108.....ACRIDIDÆ.

The Long-horned Grasshoppers.—The antennæ are very slender and longer than the body. (This is also true of the crickets.) The ovipositor is sword-shaped. The tarsi are four-jointed. p. 112.....LOCUSTIDÆ.

The Crickets.—The antennæ, like those of the long-horned grasshoppers, are very slender and longer than the body, except in the mole-crickets. The ovipositor is spear-shaped when exerted. The tarsi are three-jointed. p. 115.....GRYLLIDÆ.

Family BLATTIDÆ (Blat'ti-dæ).

The Cockroaches.

After every one is in bed at night and all is quiet in the kitchen where there are water-pipes, often a throng of little creatures come forth from hiding-places and, like brownies, take possession of everything. They race around everywhere, trying to find something to eat; they do not care much whether it is raw or cooked, but will devour almost anything that comes in reach of their greedy jaws. They eat book-bindings and bedbugs, if they find them, with equal alacrity; and sometimes they get bold enough to appear in broad daylight. The little, pale brown rascal called the Croton-bug, which came to us from Europe and infests the vicinity of the pipes of the water systems of many of our cities, is especially bold and impudent (Fig. 113). In fact, in the North our native cockroaches are mostly respectable, well-behaved insects, living in fields and forests under sticks and stones, the emigrant cockroaches being the offenders. Many cockroaches are wingless (Fig. 114). The eggs of a cockroach are laid, all at once, enclosed in a sort of pod which is more or less bean-shaped (Fig. 115). Thorough and frequent dusting with insect-powder in the cracks about the kitchen will rid a house of these pests.

FIG. 113.—The Croton-bug.

FIG. 114.—A Wingless Cockroach.

FIG. 115.—Ootheca of a Cockroach.

Family MANTIDÆ (Man'ti-dæ).

The Praying Mantes, or Mule-killers.

Certainly they are pious-looking fellows, with their front legs clasped together in front of their meek, alert faces, and

it is no wonder that they are called Praying Mantes. But the only prayer that could ever enter the mind of a Mantis

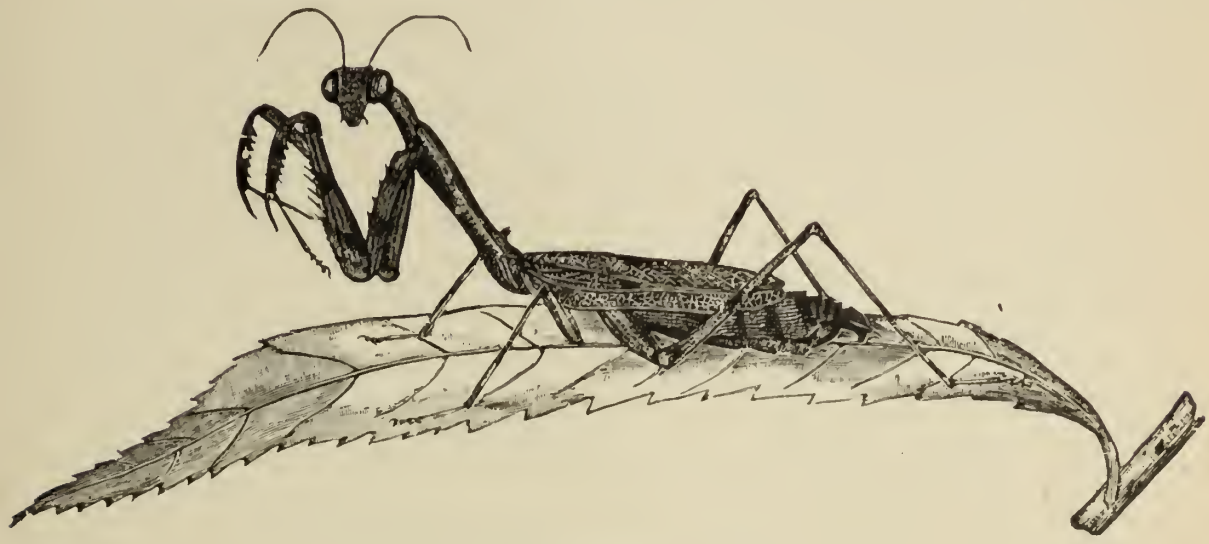

FIG. 116.—*Phasmomantis carolina.*

would be that some unwary insect might come near enough for him to grab it with his hypocritical claws, and so get a meal. Devil-horses, rear-horses, and camel-crickets are other names applied to these insects, because of the long, slender prothorax which makes them look like tiny giraffes. They are also called mule-killers, from the absurd superstition that the dark-colored saliva they eject from their mouths is fatal to the mule. But they are absolutely harmless to both man and beast. They are mostly tropical insects, and often have wings that resemble the leaves of trees. Our common species, *Phasmomantis carolina* (Phas-mo-man'tis) (Fig. 116), is confined to the Southern States. The eggs are laid in masses and overlaid with a hard covering of silk; the top of the masses having the appearance of being braided (Fig. 117).

FIG. 117.—Egg-mass of a Mantis.

Family PHASMIDÆ (Phas'mi-dæ).

The Walking-sticks.

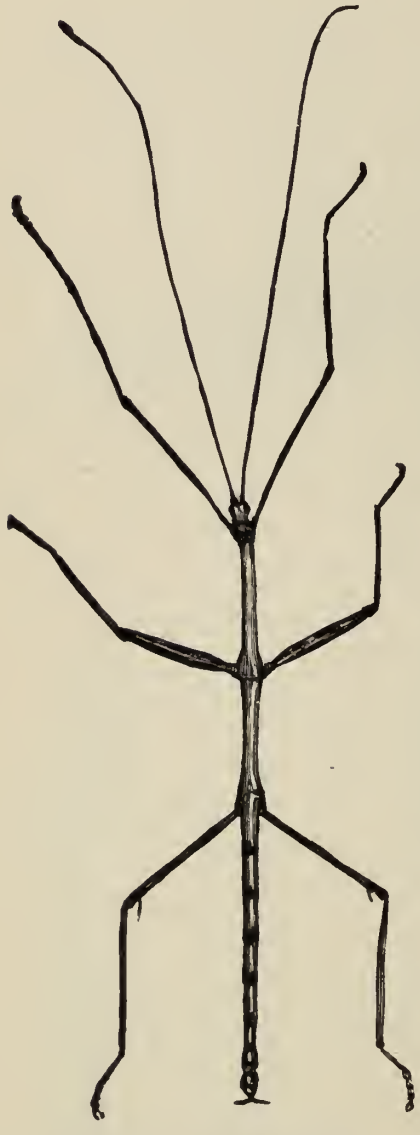

FIG. 118.—A Walking-stick.

The rambler in forests is often surprised to discover that a part of the casually-plucked branch in his hand is alive. A certain twig that was stiff and motionless suddenly, when disturbed, walks off on long slender legs, as awkwardly as if it had never tried to walk before. Strange and uncanny creatures are these walking-sticks with their long pointed bodies and with legs colored and looking exactly like twigs and leaf-petioles. In the tropics their resemblance to foliage is made more perfect by wings which are veined like leaves. In the Northern States we have only one common species, *Diapheromera femorata*, (Di-aph-e-rom'e-ra fem-o-ra'ta), and that is wingless (Fig. 118). Walking-sticks feed upon foliage. Their eggs, which are large, are dropped on the ground under the trees by the mother, who trusts entirely to fate to preserve them.

Family ACRIDIDÆ (A-crid'i-dæ).

Locusts, or Short-horned Grasshoppers.

Every country lad is familiar with the appearance of grasshoppers. But there are many kinds of these insects, representing at least two distinct families. The family Acrididæ, or Locusts, includes those grasshoppers in which

the antennæ, are shorter than the body, and in which the ovipositor of the female is short and made up of four separate plates (Fig. 119). The tarsi are three-jointed; and on

FIG. 119.—Side view of Locust with wings removed.

each side of the first segment of the abdomen there is a circular plate which is believed to be an ear.

It is to these insects that the term locust is properly applied. For the locusts of which we read in the Bible, and in other books published in the older countries, are members of this family. Unfortunately in the United States the term locust has been applied to the Periodical Cicada, a member of the order Hemiptera, described later. And, what is more unfortunate, the scientific name Locustidæ was given long ago to the next family and cannot now be changed. It should be remembered, therefore, that the locusts do not belong to the Locustidæ.

Locusts lay their eggs in oval masses and cover them with a tough substance. Some species lay their eggs in the ground. The female makes a hole in the ground with her ovipositor, which is a good digging-tool. Some species even make holes in fence-rails, logs, and stumps; then, after the eggs are laid, the hole is covered up with a plug of gummy materials. There is but one generation a year, and in most cases the winter is passed in the egg-state. This family is of great economic importance, as the members of it usually appear in great numbers in every region where plants grow, and often do much damage.

The males of many locusts are able to produce sounds. This is done in two ways: First, certain species rub the inner surface of the hind femora, upon which there is a row of minute spines, against the outer surface of the wing-covers.

In this case each wing-cover serves as a fiddle, and each hind-leg as a fiddle-bow. Second, other species rub together the upper surface of the front edge of the hind-wings and the under surface of the wing-covers. This is done while the locust is flying, and the result is a crackling sound.

There are very many species of locusts in the United States. We have space to refer to only a few here.

The most familiar member of the family is the Red-legged Locust, *Melanoplus femur-rubrum* (Me-lan'o-plus) (Fig. 120). It is more abundant than any other species throughout the United States, except in the high dry lands of the central part of the continent. Here the Rocky Mountain Locust, *Melanoplus spretus*, abounds. This species closely resembles the red-legged locust, except that it has longer wings. It is this insect that sometimes migrates into the lower and more fertile regions of the Mississippi Valley and does such great damage. It will be remembered that at one time it almost produced a famine in Kansas and the neighboring States. Fortunately the young of this insect hatched in the low regions are not healthy, and die before reaching maturity. Consequently the plagues caused by the emigration of this insect are of short duration. There are several other species of Melanoplus common in this country, but they can be distinguished only by very careful study.

FIG. 120.—*Melanoplus femur-rubrum.*

The Clouded Locust, *Encoptolophus sordidus* (En-cop-tol'-o-phus sor'di-dus) (Fig. 121), is very common in the Eastern United States during the autumn. It abounds in meadows and pastures, and attracts attention by the crackling sound made by the males during flight. Its color is dirty brown, mottled with darker spots.

FIG. 121.—*Encoptolophus sordidus.*

The Carolina Locust, *Dissosteira carolina* (Dis-sos-tei'ra), is common throughout the United States and Canada, and at the North is our largest species. It lives in roads and on bare places, and its color matches the soil on which it lives. It is usually pale yellowish or reddish-brown or slate color, with small dusky spots. The hind wings are black, with a broad yellow edge. It measures from one inch and a half to nearly two inches in length.

The Sprinkled Locust, *Chrysochraon conspersum* (Chrysoch'ra-on con-sper'sum) (Fig. 122), is a common species. Here the wings are a little shorter than the abdomen in the males, and much shorter in the females.

Fig. 122.—*Chrysochraon conspersum.*

In the South and in the West we find several genera in which the body is very long and slender. *Leptysma marginicolle* (Lep-tys'ma mar-gin-i-col'le) (Fig. 123), will serve as an illustration of the form of these insects.

Fig. 123.—*Leptysma marginicolle.*

There is a group of small locusts of which *Tettix* (Fig. 124) is an example, which is remarkable for the shape of the pronotum. This projects backward like a little roof over the wings, and often extends beyond the end of the abdomen. With these insects the wing-covers are in the shape of small rough scales, the wings being protected by the large pronotum. These insects are commonly found in low, wet places, and on the borders of streams. Their colors are usually dark, and are often protective, closely resembling that of the soil upon which they occur. These locusts are very active, jumping great distances.

Fig. 124.—*Tettix.*

Family LOCUSTIDÆ (Lo-cus'ti-dæ).

The Long-horned Grasshoppers.

Any one that is in the habit of lying in the tall grass of meadows or pastures and watching the insects that can be seen there is sure to be familiar with certain green grasshoppers, which attract attention by the extreme delicacy and great length of their antennæ. These are our most common members of the Locustidæ. The antennæ are much more slender than with the short-horned grasshoppers or locusts, and much longer, exceeding the body in length. The tarsi are four-jointed. The ear-like organs, when present, are situated near the base of the fore tibiæ (Fig. 125), and the ovipositor is sword-shaped.

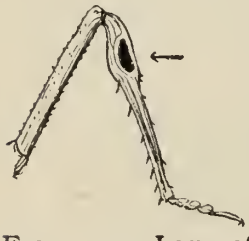

FIG. 125.—Leg of Katydid, showing ear-like organ.

In those species of this family in which the wings are well developed we find the males provided with an elaborate musical apparatus by means of which they call their mates. This consists of a peculiar arrangement of the veins and cells of a portion of each wing-cover near its base. This arrangement differs in the different species; but in each it is

FIG. 126.—Wing-cover of Male Meadow Grasshopper.

FIG. 127.—Wing-cover of Female Meadow Grasshopper.

such that by rubbing the wing-covers together they are made to vibrate, and thus produce the sound. Figure 126 represents a wing-cover of the male of a common meadow grasshopper, and Figure 127 that of a female of the same species.

In order to facilitate the study of this family the more common representatives can be arranged in four groups: The Meadow Grasshoppers, the Katydids, the Cricket-like Grasshoppers, and the Shield-backed Grasshoppers.

I. *The Meadow Grasshoppers.*—Under this head can be classed our most common members of the family; they abound upon grass in meadows and in moist places. Figure 128 represents one of these insects.

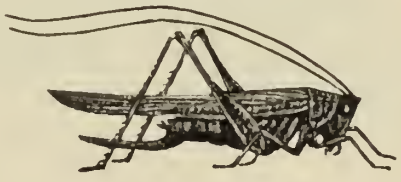

FIG. 128.—*Xiphidium.*

II. *The Katydids.*—The chances are that he who lies awake of a midsummer night must listen whether he wishes to do so or not, to an oft-repeated, rasping song that says, "Katy did, Katy did; she did, she didn't," over and over again. There is no use of wondering what Katy did or didn't do, for no mortal will ever know. If, when the dawn comes, the listener has eyes sharp enough to discern one of these singers among the leaves of some neighboring tree, never a note of explanation will he get. The beautiful, finely-veined wings folded close over the body keep the secret hidden, and the long antennæ, looking like threads of living silk, will wave airily above the droll, green eyes as much as to say, "Wouldn't you like to know?" The katydids live only on trees, and sing only during the night. There are several species of katydids common in the United States. The Western and Southern species, called the Angular-winged Katydid, *Microcentrum retinervis* (Mic-ro-cen'trum ret-i'ner-vis) lays its eggs in neat rows upon leaves and branches; the eggs are oval, and each overlaps its neighbor slightly

(Fig. 129). In many sections where the katydids do not occur, the song of the Snowy Tree-cricket, described later, is often mistaken for that of a Katydid.

FIG. 129.—The Angular-winged Katydid and its eggs.

III. *The Cricket-like Grasshoppers.*—These are wingless, and resemble crickets in form. The most common members of this group belong to the genus *Ceuthophilus* (Ceu-thoph′i-lus) (Fig. 130). These insects are found under stones and rubbish, especially in woods. Very closely allied to them are the colorless and blind Cave-crickets, *Hadenœcus* (Had-e-nœ′cus), found in caves.

FIG. 130.—*Ceuthophilus.*

IV. *The Shield-backed Grasshoppers.*—These are also wingless, and dull-colored insects, which bear some resemblance to crickets. They present, however, a queer appearance, due to the pronotum extending backward over the rest of the thorax, like a sun-bonnet worn over the shoulders with the back side forward. This group is represented in the Eastern half of the United States by *Thyreonotus* (Thyr-e-o-no'tus) (Fig. 131). In the regions west of the Mississippi River occur the "Western Crickets," belonging to the genus *Anabrus* (An'a-brus), and on the Pacific coast

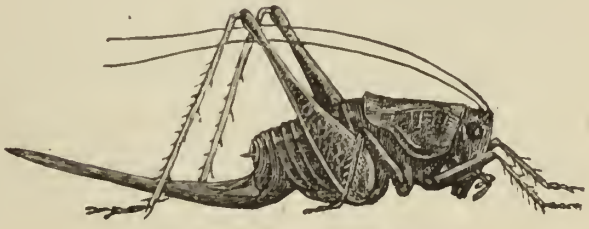

FIG. 131.—*Thyreonotus.*

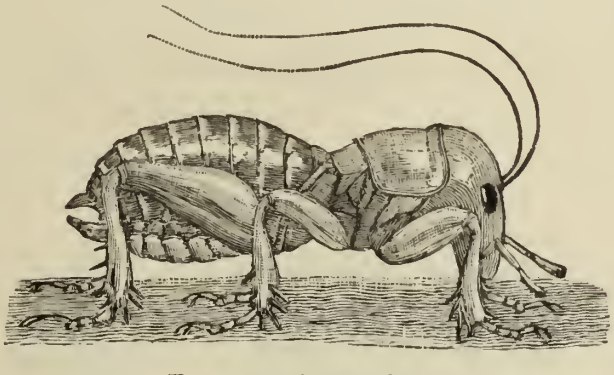

FIG. 132.—*Stenopelmatus.*

there are large, clumsy creatures with big heads, that live under stones and in loose soil, and are popularly known as Sand-crickets. These belong to the genus *Stenopelmatus* (Sten-o-pel-ma'tus) (Fig. 132).

Family GRYLLIDÆ (Gryl'li-dæ).

The Crickets.

The crickets differ from both families of grasshoppers in having the wing-covers flat above and bent sharply down at the edge of the body like a box-cover, instead of meeting in a ridge above the body like a roof. The antennæ are long

and slender, like those of the Locustidæ; but the form of the ovipositor is quite different in this family, being spear-shaped, instead of sword-like.

The males of the crickets have musical organs which are even more elaborate than those of the Katydids and meadow grasshoppers. Here all that part of each wing-cover that lies on the back is occupied by them. This gives the males a very different appearance from the females, the wing-covers of that sex being veined simply.

During the latter part of summer and in the autumn the air is filled with the chirping of crickets. It is an interesting thing to watch one of these fiddlers calling his mate. By moving quietly in the direction from which the sound comes, and stopping whenever the insect stops chirping, but moving on again when he renews his song, one can get near enough to see how he does it. This can be done even in the night with the aid of a lantern, as the crickets do not seem to mind lights.

Figure 133 represents the musical apparatus of a cricket.

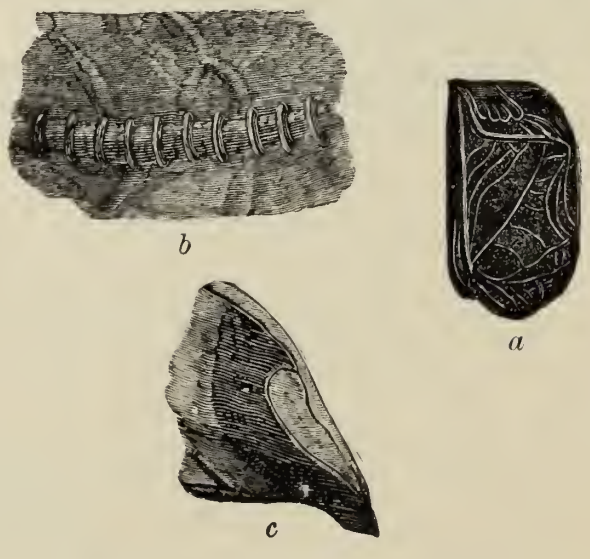

FIG. 133.—Tegmina of male *Gryllus*.

From this it will be seen that the large veins divide the wing-covers into disk-like membranous spaces. If the principal vein which extends diagonally across the base of the wing-

cover be examined with a microscope, it will be seen to be furnished with ridges like those of a file (Fig. 133, *b*). On the inner margin of the wing-cover, a short distance toward the base from the end of the principal vein, there is a hardened portion which may be called the scraper. This is shown enlarged at *c* in the figure. Each wing-cover is therefore provided with a file and a scraper. When the cricket wishes to make his call, he elevates his wing-covers at an angle of about forty-five degrees with the body; then holding them in such a position that the scraper of one rests upon the file of the other, he moves the wing-covers back and forth sidewise so that the file and the scraper rasp upon each other. This throws the wing-covers into vibration, and produces the call.

There are comparatively few species of crickets, but they represent three quite distinct groups. These can be distinguished as the Mole Crickets, the True Crickets, and the Tree Crickets.

I. *The Mole Crickets.* — These are called Mole Crickets because they burrow in the ground like moles. There are species belonging to the next group, the true crickets, which burrow in the ground; but the mole-crickets are pre-eminently burrowers. The form of the body is suited to this mode of life. The front tibiæ, especially, are fitted for digging; they are greatly broadened, and shaped somewhat like hands, or the feet of a mole. Figure 134 represents one of these insects. The mole-crickets feed upon the tender roots of various plants, and where they are common they are serious pests.

FIG. 134.—*Gryllotalpa borealis.*

II. *The True Crickets.*—To this group belong our common, black acquaintances that peep at us from the cracks

in the paving, or jump across our paths when we walk in the fields. They are common everywhere; some species even live in our houses. They usually feed upon plants, but are sometimes predaceous. The eggs are laid in the autumn, usually in the ground, and are hatched in the following summer. The greater number of the old crickets die on the approach of winter; a few, however, survive the cold season. Figure 135 represents the female of a species common in the East. In this species the wings are shorter than usual.

FIG. 135.—*Gryllus abbreviatus.*

III. *The Tree Crickets.*—The common name of this group was suggested by the fact that these crickets are very apt to inhabit trees; but they occur also on shrubs, or even on high herbs and tall grass. The most abundant species in the East is the Snowy Tree-cricket, *Œcanthus niveus* (Œ-can'thus niv'e-us). This is a delicate, whitish-green insect, that lives upon shrubs or plants. The female often does serious damage by laying her eggs in raspberry canes, causing them to die above the puncture. Canes thus injured should be cut and burned in the early spring before the eggs are hatched. Figure 136 shows the male, his closely folded wings showing beneath his delicate transparent wing-covers. The female has her wing-covers wrapped closely around her body, making her look much narrower than the male.

FIG. 136.—*Œcanthus niveus*, male.

CHAPTER XIII.

Order PHYSOPODA (Phy-sop'o-da).

Thrips.

The members of this order have four wings; these are similar in form, long, narrow, membranous, not folded, with but few or no veins, and only rarely with cross veins; they are fringed with long hairs, and are laid horizontally along the back when at rest. The metamorphosis is incomplete. The mouth-parts are probably used chiefly for sucking; they are intermediate in form between those of the sucking and those of the biting insects (*Fig.* 138); *the mandibles are bristle-like; the maxillæ are triangular, flat, and furnished with palpi; and the labial palpi are also present. The tarsi are two-jointed, bladder-like at tip, and without claws.*

Pull to pieces a clover-blossom or a daisy, and you will probably find at the base of the florets many wee, black, red, or yellowish insects. These are so small that it would take a dozen or more placed end to end to measure an inch; and when disturbed they are apt to thrust the end of their bodies up in the air as if they meant to sting, looking as ferocious as such small insects can look. They are extremely lively, leaping or taking flight with great agility. Under a microscope their four narrow wings, delicately fringed all around with long hairs, may be seen; these wings are laid flat down the back when at rest. The red ones are wingless, and are the young of the black species. Some species eat other insects, but most of them live upon vegetation. There is one species, *Limothrips poaphagus* (Lim'o-thrips po-aph'a-

gus) that damages timothy and June-grass very much by working in the upper joints. In the early summer the dead and yellow heads of grasses thus destroyed may be seen everywhere in grass-growing regions. Some species live under the bark of trees. The accompanying figure represents one of these insects very greatly enlarged (Fig. 137).

FIG. 137.—*Thrips.*

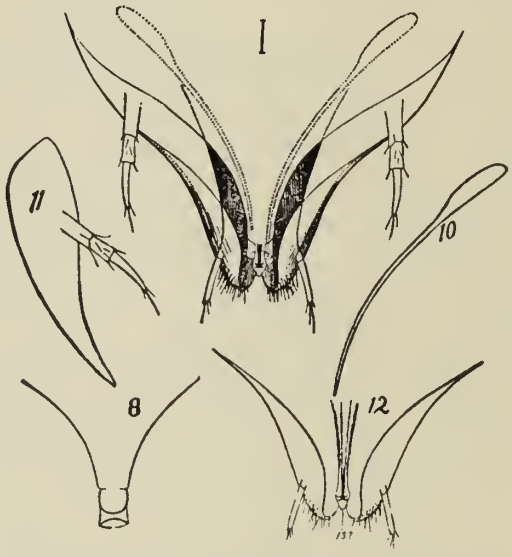

FIG. 138.—Mouth-parts of *Thrips*. (Drawn by J. M. Stedman, under the author's direction.) 8, labrum; 10, mandible; 11, maxilla; 12, labium.

The insect infesting grapes, called "The Thrips," is not a Thrips at all, but a leaf-hopper belonging to the Homoptera.

The name Physopoda is from two Greek words: *physao*, to blow up, and *pous*, a foot. It refers to the curious bladder-like feet of these insects. Figure 138 represents the mouth-parts of Thrips.

CHAPTER XIV.

Order HEMIPTERA (He-mip'te-ra).

Bugs, Lice, Aphids, and others.

The winged members of this order have four wings; in one sub-order the first pair of wings are thickened at the base, with thinner extremities which overlap on the back; in another sub-order the first pair of wings are of the same thickness throughout, and usually slope at the sides of the body. The mouth-parts are formed for sucking. The metamorphosis is incomplete.

The order Hemiptera includes many well-known pests: here belong the true bugs, the lice, the aphids, the scale insects, and many other forms injurious to plants. On the other hand, some of the species are ranked among beneficial insects on account of their predaceous habits; while still others, as the cochineal and lac insects, furnish us with useful products.

The name Hemiptera is from two Greek words: *hemi*, half; and *pteron*, a wing. It was suggested by the form of the first pair of wings in the true bugs. Here the basal half of these organs is thickened somewhat like the wing-covers of beetles, only the terminal half being wing-like. The second pair of wings are membranous, and when at rest are folded beneath the first pair.

The mouth-parts are formed for piercing and sucking. Without dissection, they usually appear as a slender jointed beak, arising at the base of a shorter, pointed upper lip. This beak consists of four bristles, enclosed in a fleshy,

jointed sheath (Fig. 139). Two of the bristles represent the mandibles, and two the maxillæ. The sheath is supposed to consist of the labium and the grown-together labial palpi.

In their transformation the Hemiptera pass through an incomplete metamorphosis; the young nymphs resembling

FIG. 139.—Mouth-parts of Bug. (After Muhr.)

FIG. 140, *a*.—Head of an heteropterous insect.

FIG. 140, *b*. — Head of an homopterous insect.

the adults more or less closely in form, and the wings being gradually developed at successive molts.

This order includes three well-marked groups, which are ranked as suborders. The first of these, the *Heteroptera*, includes the true bugs. They are placed first, as we believe they resemble the ancient Hemiptera—the first to appear on the earth—more closely than the members of either of the other suborders. The second suborder, the *Parasitica*, includes the lice. These insects are much lower in structure than the Heteroptera; but we believe that this simplicity in structure is a result of degradation due to parasitic habits, and therefore really represents a later development than that shown by the Heteroptera. In other words, the lice are probably descendants of some ancient form resembling some of the existing Heteroptera. Among the Heteroptera the bedbug exhibits a similar downward tendency. The third suborder, the *Homoptera*, includes some forms that

are perhaps as primitive as any of the existing Heteroptera, but, on the other hand, we find here forms that represent the widest divergence from the hemipterous type known to us.

These three suborders can be separated by the following table:

A. Wingless Hemiptera, parasitic upon man and other Mammals, with a fleshy, unjointed beak p. 147.....II. PARASITICA.

AA. Hemiptera with or without wings, but with a jointed beak.

B. First pair of wings thickened at the base, with thinner extremities, which overlap on the back; beak arising from the front part of the head (Fig. 140, *a*). p. 123. ....I. HETEROPTERA.

BB. Wings of the same thickness throughout, and usually sloping at the sides of the body; beak arising from the hinder part of the lower side of the head (Fig. 140, *b*) p.148.III. HOMOPTERA.

Suborder HETEROPTERA (Het-e-rop'te-ra).

The True Bugs.

People that know but little regarding entomology are apt to apply the term bug to any kind of insect; but, strictly speaking, only the Hemiptera are bugs, and many restrict the term to members of this suborder. We therefore designate the Heteroptera as the True Bugs.

The bugs are very common insects. They abound on grass and on the foliage of other plants. Certain foul-smelling members of this group are well-known pests in gardens, and upon berries in fields.

In this suborder the first pair of wings are thickened at the base, while the tips, which overlap each other on the back of the insect, are thin and transparent; and the beak arises from the front part of the head (Fig. 140, *a*). Some of the Heteroptera live in water, others on land, while still others live on the surface of the water or in marshy places. Each of these modes of life are characteristic of certain families. The name Heteroptera is from the Greek *heteros*, diverse, and *pteron*, a wing. The following synopsis will aid

the student in learning the characters of the families of this suborder:

SYNOPSIS OF THE HETEROPTERA.

THE SHORT-HORNED BUGS. Bugs with short antennæ, which are nearly or quite concealed beneath the head.

Bugs that live within water.

The Water-boatmen, Family CORISIDÆ. (p. 129.)

The Back-swimmers, Family NOTONECTIDÆ. (p. 130.)

The Water scorpions, Family NEPIDÆ. (p. 130.)

The Giant Water-bugs, Family BELOSTOMIDÆ. (p. 131.)

The Creeping Water-bugs, Family NAUCORIDÆ. (p. 133.)

Bugs that live near water.

The Toad-shaped Bugs, Family GALGULIDÆ. (p. 133.)

THE LONG-HORNED BUGS. Bugs with antennæ at least as long as the head, and prominent except in the *Phymatidæ*, where they are concealed under the sides of the prothorax.

The Semi-aquatic Bugs.

The Shore-bugs, Family SALDIDÆ. (p. 134.)

The Broad-shouldered Water-striders, Family VELIIDÆ. (p. 134.)

The Water-striders, Family HYDROBATIDÆ. (p. 135.)

The Marsh-treaders, Family LIMNOBATIDÆ. (p. 136.)

The Land-bugs.

The Land-bugs with four-jointed antennæ.

The Thread-legged Bugs, Family EMESIDÆ. (p. 136.)

The Assassin-bugs, Family REDUVIIDÆ. (p. 137.)

The Damsel-bugs, Family NABIDÆ. (p. 138.)

The Ambush-bugs, Family PHYMATIDÆ. (p. 138.)

The Flat bugs, Family ARADIDÆ. (p. 139.)

The Lace-bugs, Family TINGITIDÆ. (p. 139.)

The Bed-bug and the Flower-bugs, Family ACANTHIIDÆ. (p. 140).

The Leaf-bugs, Family CAPSIDÆ. (p. 140.)

The Red-bug Family, Family PYRRHOCORIDÆ. (p. 141.)

The Chinch-bug Family, Family LYGÆIDÆ. (p. 142.)

The Stilt-bugs, Family BERYTIDÆ. (p. 143.)

The Squash-bug Family, Family COREIDÆ. (p. 143.)

The Land-bugs with five-jointed antennæ.

The Stink-bug Family, Family PENTATOMIDÆ. (p. 144.)

The Burrower-bugs, Family CYDNIDÆ. (p. 145).

The Negro-bugs, Family CORIMELÆNIDÆ. (p. 146.)

The Shield-backed bugs, Family SCUTELLERIDÆ. (p. 146.)

Classification of the Heteroptera.

(*For advanced students*)

In order to use the following table for determining the families of bugs, the student should become familiar with the names applied to different parts of the fore-wings of these insects. The thickened basal portion is composed of two pieces joined together at their sides; one of these is narrow and is the part next to the scutellum when the wings are closed (Fig. 141, *cl*); this is distinguished as the *clavus* (cla'vus). The other broader part is the *corium* (co'ri-um) (Fig. 141, *co*). The terminal portion of the wing-cover is designated as the *membrane* (Fig. 141, *m*.) In certain families a triangular portion of the terminal part of the corium is separated as a distinct piece; this is the *cuneus* (cu'ne-us) (Fig. 141, *cu*). In certain other cases, a narrow piece on the costal margin of the corium is separated by a suture; this is the *embolium* (em-bo'li-um) (Fig. 141, *e*).

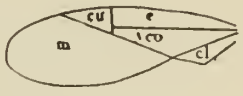

FIG. 141.—Diagram of wing-cover of a bug.

FIG. 142.
Nabidæ.

FIG. 143.
Acanthiidæ.

FIG. 144.
Capsidæ.

FIG. 145.
Pyrrhocoridæ.

FIG. 146.
Lygæidæ.

FIG. 147.
Coræidæ.

TABLE FOR DETERMINING THE FAMILIES OF THE HETEROPTERA.

A Antennæ shorter than the head, and nearly or quite concealed in a cavity beneath the eyes.

B. Hind-tarsi without claws.

C. Fore-tarsi flattened with a fringe of hairs on the edge, and without claws; head overlapping the prothorax. p. 129. CORISIDÆ.

CC. Fore-tarsi of the usual form, and with two claws; head inserted in the prothorax. p. 130. ..... NOTONECTIDÆ.

BB. Hind-tarsi with two claws.

C. Caudal end of the abdomen furnished with a respiratory tube composed of a pair of grooved, thread-like organs. p. 130. NEPIDÆ.

CC. Caudal end of abdomen without respiratory tube.

D. Legs flattened, fitted for swimming; caudal end of the abdomen furnished with a pair of strap-like appendages (these appendages are retractile and are frequently withdrawn from sight). p. 131 ..... BELOSTOMIDÆ.

DD. Legs fitted for walking; abdomen without strap-like caudal appendages.

E. Without ocelli. p. 133 ..... NAUCORIDÆ.

EE. Ocelli present. p. 133 ..... GALGULIDÆ.

AA. Antennæ at least as long as the head, usually free, rarely (*Hymatidæ*) fitting in a groove under the lateral margin of the pronotum.

B. Body linear; head as long as the three thoracic segments. p. 136 ..... LIMNOBATIDÆ.

BB. Body of various forms, but, when linear, with the head shorter than the thorax.

C. Last segment of the tarsi more or less split, and with the claws inserted before the apex.

D. Body usually elongated; prothorax narrow; beak four-jointed; second and third pairs of legs extremely long and slender. p. 135 ..... HYDROBATIDÆ.

DD. Body usually stout, oval, and broadest across the prothorax; beak three-jointed; legs not extremely long. p. 134. VELIIDÆ.

CC. Last segment of the tarsi entire, and with the claws inserted at the apex.

D. Antennæ four-jointed.*

E. Wing-covers resembling network, and very rarely (*Piesma* with any distinction between the corium and the membrane. p. 139 ..... TINGITIDÆ.

EE. Wing-covers of various forms or absent, but not of the form presented by the Tingitidæ. See Fig. 165.

F. Beak three-jointed.

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* In certain families there are minute intermediate segments between the principal segments of the antennæ. For the purposes of this table these intermediate segments are not counted.

G. Wing-covers when well developed with a cuneus (Fig. 143); those forms in which the adult has rudimentary wing-covers have no ocelli. p. 140....ACANTHIIDÆ.

GG. Wing-covers when well developed without a cuneus; those forms in which the adult has rudimentary wing-covers have ocelli.

H. Ocelli wanting.

I. Body linear. p. 136..... EMESIDÆ.

II. Body greatly flattened. p. 139. .... ARADIDÆ.

III. Body of ordinary form. p. 137. REDUVIIDÆ.

HH. Ocelli present, though sometimes difficult to see.

I. Beak very long, reaching to or beyond the intermediate coxæ. p. 134. ..... SALDIDÆ.

II. Beak not reaching the intermediate coxæ.

J. Front legs with greatly thickened femora. p. 138..... PHYMATIDÆ.

JJ. Front femora somewhat thickened, but much less than half as wide as long. p. 137. REDUVIIDÆ.

FF. Beak four-jointed.

G. Front legs fitted for grasping prey, the tibiæ being armed with spines and capable of being closed tightly upon the femora, which are stout. In the forms with long wings the membrane is usually furnished with four long veins, bounding three discal cells which are often open. From these cells diverge veins which form several marginal cells. (Fig. 142). p. 138. NABIDÆ.

GG. Front legs fitted for walking.

H. Wing-covers with cuneus. Membrane with one or two closed cells at its base, otherwise without veins. (Fig. 144.) p. 140... ..... CAPSIDÆ.

HH. Wing-covers without cuneus. Membrane with four or five simple or anastomosing veins arising from the base; or with a large number of veins arising from a cross-vein at the base.

I. Ocelli wanting; membrane with two large cells at the base, and from these arise about eight branching veins. (Fig. 145.) p. 140. PYRRHOCORIDÆ.

II. Ocelli usually present.

J. Head with a transverse incision in front of the ocelli, which are always present. (Fig. 175.) p. 143. ..... BERYTIDÆ.

JJ. Head without transverse incision.

K. Membrane with four or five simple veins arising from the base of the membrane; the two inner ones sometimes joined to a cell near the base. (Fig. 146.) p. 142..... LYGÆIDÆ.

KK. Membrane with many, usually forked veins, springing from a transverse basal vein. (Fig. 147.) p. 143..... COREIDÆ.

DD. Antennæ five-jointed.

E. Scutellum nearly flat, narrowed behind.

F. Tibiæ unarmed or furnished with very short spines. p. 144..... PENTATOMIDÆ.

FF. Tibiæ armed with strong spines in rows. p. 145. CYDNIDÆ.

EE. Scutellum very convex, covering nearly the whole abdomen.

F. Lateral margins of the scutellum with a furrow in which the edge of the wing-cover fits when closed. p. 146..... ..... CORIMELÆNIDÆ.

FF. Lateral margins of the scutellum without a furrow. p. 146. .... SCUTELLERIDÆ.

In the following pages we have discussed the families of the Heteroptera in the order in which they are commonly arranged by writers on these insects. The aquatic families are placed first, the semi-aquatic next, and the terrestrial last. We do not believe, however, that this represents well the lines of development of these insects. It seems probable to us that some of the terrestrial forms, as the Pentatomidæ, resemble the ancient Heteroptera more closely than do the aquatic forms; and that the aquatic forms are really very highly specialized and represent the summit of one of the lines of development. Perhaps the Scutelleridæ represent the summit of another line. But as we have been unable to give the matter sufficiently thorough study to warrant our proposing a new arrangement, it seems best to follow the old one, merely indicating our belief in the necessity for a revision of the suborder.

Family CORISIDÆ (Co-ris'i-dæ).

The Water-boatmen.

These are oval, gray and black, mottled bugs, usually less than half an inch in length, which occur in the streams, ponds, and lakes of the whole United States. The characteristic form and markings of these insects are shown in Figure 148. These Water-boatmen have the body flattened above, and swim upon the ventral surface; in these respects they differ from the members of the next family.

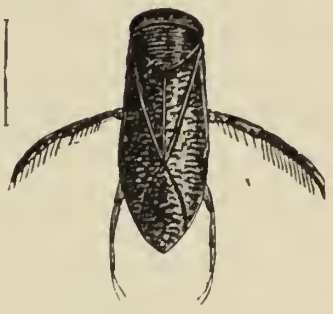

FIG. 148.—*Corisa undulata.*

The body of these insects, as they swim through the water, is almost completely enveloped in air, which glitters like a silver armor. This air is breathed by the insects while they remain under water, and in good water it is purified by contact with the fine particles of air scattered through the water; so that the insects can breathe their coats of air again and again indefinitely. This is the case especially when they are in their favorite attitude, anchored near the bottom of a pond or aquarium. Here they will remain for a long time clinging to some object by their fore legs, and with their hind legs stretched out sidewise; these they move frequently as when swimming. The result of this movement is to cause a current of water to pass over the coat of air, purifying it.

The body of these insects with the air clinging to it is much lighter than water; consequently, whenever they loose their hold upon the object to which they have been clinging, they rise quickly to the surface, unless they prevent it by swimming. They occasionally float on the surface of the water, and can leap into the air from the water and take flight. They feed upon other insects and lay their eggs upon water-plants. All of the North American species of this family belong to the genus *Corisa* (Cor'i-sa).

Family NOTONECTIDÆ (No-to-nec'ti-dæ).

The Back-swimmers.

The Back-swimmers have the back shaped like the bottom of a boat, instead of flat like the true water-boatmen and they differ from all other aquatic bugs in that they always swim on their backs.

The favorite attitude of the Back-swimmers is floating on the surface of the water, back downward, with the hind end of the body projecting sufficiently to admit of air being drawn into the space beneath the wings. When in this position their long oar-like hind legs are stretched outward and forward, ready for action. When disturbed they dart away toward the bottom of the pond, carrying a supply of air beneath their wings. Occasionally these insects will float on the surface of the water with their backs uppermost; and, like the water-boatmen, they can leap into the air from the water and take flight.

The Back-swimmers feed upon insects and other small animals. In collecting them care must be taken or they will inflict painful stings with their sharp and powerful beaks.

FIG. 149.—*Notonecta undulata.*

The greater number of our common species of this family belong to the genus *Notonecta* (No-to-nec'ta) (Fig. 149).

Family NEPIDÆ (Nep'i-dæ).

The Water-scorpions.

The Water-scorpions have two long bristles on the end of the body, which are grooved on the inner side. By putting these bristles together a long tube is formed, which the insects can project to the surface of the water, and thus obtain air for breathing, while resting on the bottom of the

pond, stilted on their long legs, or clinging head downward to the stems of plants.

The most common members of this family belong to the genus *Ranatra* (Ran'a-tra) (Fig. 150). These are long, slender bugs with long, slender legs. The only other representative of the family found in the United States is *Nepa apiculata* (Ne'pa a-pic-u-la'ta). In this species the body is oval, flat, and thin, and measures about two thirds of an inch in length, not including the breathing-tube, which is a little more than one fourth of an inch long. (See Fig. 214, p. 174.)

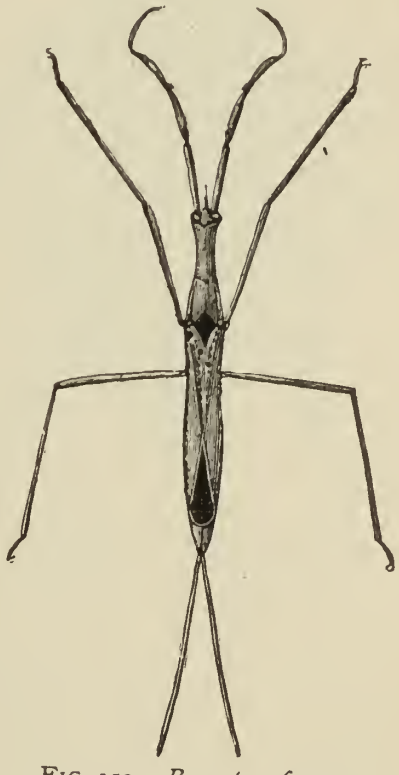

FIG. 150.—*Ranatra fusca.*

The Water-scorpions live among rubbish or on the stems of water-plants, in ponds and in the quiet parts of our streams. They are carnivorous, and have the first pair of legs fitted for seizing prey. In these legs the coxa is very long, and the femur is furnished with a groove into which the tibia and tarsus fit like the blade of a pocket-knife into the handle.

Owing to the linear form of the body of *Ranatra*, and to the dirt with which it is usually covered, it is quite difficult to detect the presence of this insect among the rubbish where it is found. Doubtless this resemblance to a dirty stick aids it greatly in the capture of insects, small fish, and other unwary animals upon which it preys.

Family BELOSTOMIDÆ (Bel-os-tom'i-dæ).

The Giant Water-bugs.

We have named these insects the Giant Water-bugs as the family includes the largest Heteroptera now in existence.

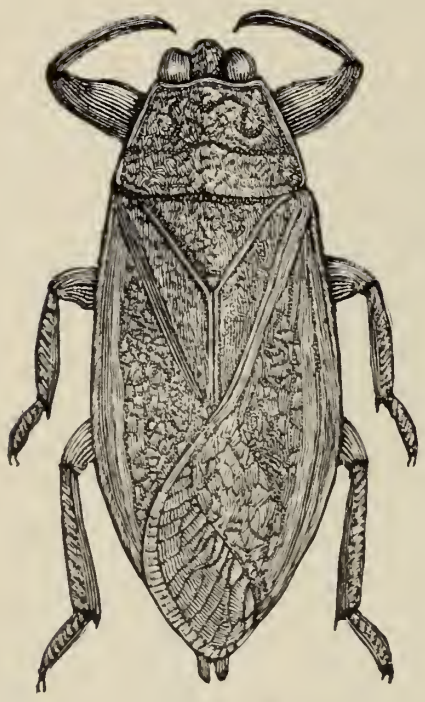

FIG. 151.—*Belostoma americanum.*

Figure 151 represents a common form, natural size. Like other water-bugs, these insects fly readily from pond to pond, and they are frequently attracted to lights. This is especially the case where electric lights are used, into which they sometimes fly and are killed by hundreds. On this account they are known in many parts of the country as "Electric-light Bugs;" and in some sections the absurd idea prevails that they have appeared only recently, as if they were in some way a product of the electric light.

Figure 151 represents *Belostoma americanum* (Be-los'to-ma a-mer-i-ca'num). In Belostoma the front femora are grooved for the reception of the tibiæ, as in the preceding family. Another common representative of the family is *Benacus griseus* (Be-na'cus gris'e-us). This resembles *Belostoma americanum* very closely, but can be distinguished from it by the absence of the femoral groove.

There are other species of the family which are smaller and belong to the genus *Zaitha* (Za'i-tha). Figure 152 represents one of these, natural size.

FIG. 152.—*Zaitha fluminea.*

In the far West there is a common species which is an inch and a half long and about half as broad; this is *Serphus dilatatus* (Ser'phus dil-a-ta'tus). These insects are known to California children as "Toe-biters," owing to the great interest they are supposed to take in the feet of waders and swimmers.

The Giant Water-bugs are rapacious creatures, feeding on other insects and small fish. With

many of them the female fastens her eggs on the top of her own back with a thin layer of waterproof glue which she secretes for this purpose.

Family NAUCORIDÆ (Nau-cor'i-dæ).

The Creeping Water-bugs.

This is a small family containing water-bugs of a moderate size, in which the front legs are fitted for grasping and the middle and hind legs for walking. They are flat-bodied, chiefly oval insects, and without appendages at the hind end of the body.

The members of this family are predaceous ; and, according to Professor Uhler, they are fond of reedy and grassy, quiet waters, where they creep about like the Predaceous Diving-beetles, creeping and half swimming around and between the leaves and sprays of the submerged plants, and suddenly seizing any unlucky water-boatman or other insect that happens to be within reach.

Figure 153 represents *Pelocoris femorata* (Pe-loc'o-ris fem-o-ra'ta), the only species found in the States on the Atlantic coast. Several other species are found in the Western States. These belong to the genus *Ambrysus* (Am-bry'sus), which differs from Pelocoris in having the front margin of the prothorax very deeply sinuate.

FIG. 153.—*Pelocoris.*

Family GALGULIDÆ (Gal-gu'li-dæ).

The Toad-shaped Bugs.

There is sometimes found on the muddy margins of streams or in marshes, where the soil is moist, a curious bug, which on account of its short and broad body and projecting eyes reminds one of a toad ; this is *Galgulus oculatus* (Gal'gu-

lus oc-u-la′tus) (Fig. 154), the most common member of this family. Another species, *Mononyx stygicus* (Mon′o-nyx styg′i-cus), closely resembles this one in form, but can be distinguished by the fact that it has only a single claw on each front tarsus. A third member of the family is *Pelogonus americanus* (Pe-log′o-nus a-mer-i-ca′nus); this is a smaller insect, with a more oblong body, and of a velvety-black color. These three are all of the species of this family that have been found in the United States. They all are predaceous. Some members of this family are known to make burrows for themselves, and to live for a part of the time beneath the ground.

FIG. 154.—*Galgulus oculatus.*

Family SALDIDÆ (Sal′di-dæ).

The Shore-bugs.

These are certain small bugs, of dark colors with white or yellow markings, and with long antennæ, which abound in the vicinity of streams and lakes, and upon damp soils, especially of marshes near our coasts. The shape of these Shore-bugs is shown by Figure 155; they belong to the genus *Salda*, the only genus representing this family in the United States, although many species occur here.

FIG. 155.—*Salda.*

Some of the Shore-bugs dig burrows, and live for a part of the time beneath the ground. They take flight quickly when disturbed, but alight after flying a short distance.

Family VELIIDÆ (Ve-li′i-dæ).

The Broad-shouldered Water-striders.

There are many bugs that run upon the surface of the water. The greater number of them belong to the next family; but there are several genera which represent a family distinct from the true Water-striders, and which can be easily distinguished from them by the fact that the body is broad-

est across the prothorax. These Broad-shouldered Water-striders constitute the family *Veliidæ*. They pass the greater part of their lives upon the surface of the water, often congregating in schools containing hundreds of individuals; but they usually remain near the banks of the stream or pond, and sometimes they leave the water, moving on the land with great freedom. Like the members of the allied families, they are predaceous. Figure 156 represents one of these insects somewhat enlarged.

FIG. 156.—*Rhagovelia collaris.*

Family HYDROBATIDÆ (Hyd-ro-bat'i-dæ).

The Water-striders.

On the quiet pools of a running stream or the calm waters of a protected pond may be found swarms of slender long-legged insects that seem to find the water surface a pavement well suited for their airy feet. If your approach is stealthy you may see them resting motionless as if absorbed in gazing at their own reflections in the mirror below them; but disturb them, and so swiftly do they move that they seem but darting lines as they circle around and around each other in a mystic dance. If you watch them closely you may see one leap into the air after some approaching insect.

These are the true Water-striders. In some of them the body is long and narrow, as shown in Figure 157; in others it is oval; but in all it is widest back of the prothorax, thus differing from the form seen in the preceding family.

FIG. 157.—*Hygrotrechus conformis.*

In the winter they stow themselves away under the banks or at the bottom of the water, and do not come to

the surface until lured there by the warm weather of spring. They then lay their eggs, gluing them fast to water-plants.

There are members of this family that live on the surface of the ocean, hundreds of miles from land.

Family LIMNOBATIDÆ (Lim-no-bat'i-dæ).

The Marsh-treaders.

Only a single species of this family, the Marsh-treader, *Limnobates lineata* (Lim-nob'a-tes lin-e-a'ta), is found in the United States. This is represented greatly enlarged by Figure 158. Although not an uncommon species, it is rarely seen on account of its small size and quiet habits. It can be recognized by its linear form and the great length of its head, which is longer than the thorax. It crawls about on the surface of the water or mud, or climbs upon water-plants and sticks projecting from the water; it seems to prefer stagnant ponds or marshes. We do not know upon what it feeds.

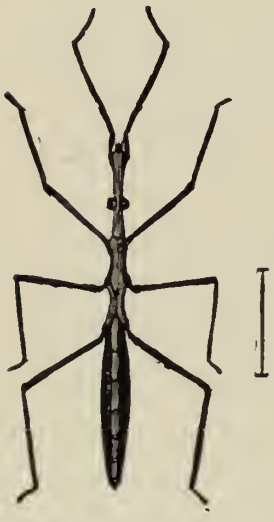

FIG. 158.—*Limnobates lineata.*

Family EMESIDÆ (E-mes'i-dæ).

The Thread-legged Bugs.

This family includes a small number of insects in which the body is very slender and the middle and hind legs are thread-like; but the fore legs are fitted for grasping, resembling much those of the Mantes. Our most common species is the Long-legged Emesa, *Emesa longipes* (Em'e-sa lon'-gi-pes), which is represented by Figure 159. This is found upon trees, or sometimes swinging by its long legs from the roofs of sheds or barns. It is predaceous.

FIG. 159.—*Emesa longipes.*

Family REDUVIIDÆ (Red-u-vi'i-dæ).

The Assassin-bugs.

There are many bugs which destroy their fellows, but the members of this family are so pre-eminently predaceous that we call them the Assassin-bugs. Although they usually live on the blood of insects, in some cases they attack the higher animals, and occasionally even man suffers from them. Care should be used in collecting them, as some are apt to inflict painful stings with their beaks. In this family the beak is only three-jointed, and when not in use the tip rests in a groove between the fore legs. The family is a very large one, containing more than a hundred American species.

In the Atlantic States one sometimes finds, in basements and in rooms but little used, a bug which presents a very curious appearance from having its body and legs completely covered with dust, so that it looks like a living mass of lint as it moves around. This is the Masked Bed-bug Hunter, *Opsicœtus personatus* (Op-si-cœ'tus per-so-na'tus). This species infests houses for the sake of preying upon bed-bugs; it also feeds upon flies and other insects. Its mask is worn only during youth, and consists of particles of dust and fibres which adhere to a sticky substance with which the body, legs, and antennæ are covered. The adult is black or very dark brown, and is represented by Figure 160.

FIG. 160.—*Opsicœtus personatus.*

A closely allied species, which is black marked with red, insinuates itself into beds for a less commendable purpose than that of its ally, for it sucks human blood at first hand. This insect occurs in the Southern and Western States; it is the Big Bed-bug, *Conorhinus sanguisugus* (Co-nor'hi-nus san-gui-su'gus). Nearly all the members of this family, however, live upon trees and other plants, and prey upon insects.

Family NABIDÆ (Nab'i-dæ).

The Damsel-bugs.

We have called the members of this family the Damsel-bugs for want of a better name, "little girl" being the meaning of *Coriscus*, the scientific name of our most common genus.

Figure 161 represents a wing-cover of a member of this family, and will illustrate the venation characteristic of it, although in some species the wings are usually rudimentary. We have two common members of this family, one blonde and the other black.

FIG. 161.

The Blonde Damsel-bug, *Coriscus ferus* (Co-ris'cus fe'rus), is about one-third inch in length, and pale yellow, with numerous minute brown dots. This species is widely distributed, both in this country and in Europe. It secretes itself in flowers or among the foliage of various herbaceous plants, and captures small insects, upon which it feeds. There are several other species that closely resemble this one.

FIG. 162. — *Coriscus subcoleoptratus.*

The Black Damsel-bug, *Coriscus subcoleoptratus* (sub-co-le-op-tra'tus) (Fig. 162), is very common in the Northern States. It is of a shining jet-black color, with the edge of the abdomen and the legs yellowish. Usually this species has very short, rudimentary wings, but a form with long wings is sometimes found.

Family PHYMATIDÆ (Phy-mat'i-dæ).

The Ambush-bugs.

The most common member of this family is *Phymata wolffii* (Phy-ma'ta wolf'i-i) (Fig. 163). It is a greenish insect, with a black band across the broadly expanded abdomen. It conceals itself in flowers, and captures the insects which come to sip nectar. It is especially abundant among the flowers of the golden-rod.

FIG. 163. *Phymata wolffii.*

It has wonderfully strong, grasping front legs, and can overcome insects much larger than itself.

Family ARADIDÆ (A-rad'i-dæ).

The Flat-bugs.

These are the flattest of all bugs, the body appearing as if it had been stepped upon. They live in the cracks or under the bark of decaying trees. The form of the body is especially adapted for gliding about in these cramped situations. They are usually of a dull-brown color, but are sometimes varied with reddish or pale markings. Figure 164 represents a common species.

FIG. 164. *Aradus acutus.*

Family TINGITIDÆ (Tin-git'i-dæ).

The Lace-bugs.

Dainty as fairy brides are these tiny, lace-draped insects. One glance at the fine white meshes that cover the wings and spined thorax is sufficient to distinguish them from all other insects, for these are the only ones that are clothed from head to foot in fine white Brussels net. They live upon

FIG. 165.—*Corythuca arcuata.* (From the Author's Report for 1879.)

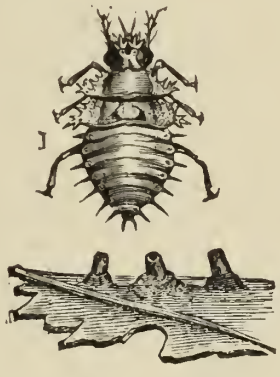

FIG. 166.—Eggs and nymph of *Corythuca arcuata.* (From the Author's Report for 1879.)

the juices of plants, and in the case of the Hawthorn Tingis (Fig. 165) sometimes prove too numerous for the health of their plant host.

They are very small insects, rarely measuring more than one eighth of an inch in length. Their eggs are fastened to leaves, and covered by a brown, sticky substance; they appear more like fungi than like the eggs of other insects (Fig. 166).

Family ACANTHIIDÆ (Ac-an-thi'i-dæ).

The Bed-bug and the Flower-bugs.

The Bed-bug, *Acanthia lectularia* (A-can'thi-a lec-tu-la'-ri-a), is a well-known pest over the greater part of the world. It is reddish brown in color, and measures when full-grown from one-sixth to one-fifth inch in length. The body is ovate in outline and is very flat (Fig. 167). It is wingless, or has very short and rudimentary wing-covers.

FIG. 167.—*Acanthia lectularia.*

The Bed-bug is a nocturnal insect, hiding by day in the cracks of furniture and beneath various objects. Bed-bugs are easily destroyed by wetting the cracks in which they hide with corrosive sublimate dissolved in alcohol. This is sold by druggists under the name of bed-bug poison. Pyrethrum powder blown into the cracks will destroy these insects, and, unlike corrosive sublimate, is not poisonous to man. A closely allied species, *A. hirundinis* (hir-un-di'nis) occurs in nests of the barn-swallow.

There are certain small bugs that are closely allied to the Bed-bug, but which have wing-covers that are almost always fully developed. These are the Flower-bugs. They are found in a great variety of situations, often upon trees and flowers, sometimes under bark or rubbish. They are predaceous. Figure 168 represents a wing-cover of one of these insects.

FIG. 168.

Family CAPSIDÆ (Cap'si-dæ).

The Leaf-bugs.

This is the largest family of the Heteroptera; the members of it live chiefly upon the leaves of plants,

from which they derive their nourishment, but some of them are predaceous. The most available character for distinguishing these insects is the structure of the wing-covers; at the base of the membrane there are one or two cells, otherwise the membrane is without veins (Fig. 169).

FIG. 169.

More than two hundred species belonging to this family are known to occur in the United States. Figure 170 represents the Four-lined Leaf-bug, *Pœcilocapsus lineatus* (Pœ-cil-o-cap'sus lin-e-a'tus), a yellow bug, with its prothorax and wing-covers marked with black, which is abundant in early summer on the leaves of currant-bushes and of sage.

FIG. 170.—*Pœcilocapsus lineatus.*

Family PYRRHOCORIDÆ (Pyr-rho-cor'i-dæ).

The Red-bug Family.

The members of this family are rather stout and heavily formed bugs, and are generally black or brown, marked with red. Some members of the next family resemble these in markings, but the two families can be distinguished by the venation of the membrane of the wing-covers. In this family there are two large cells at the base of the membrane, and from these arise branching veins (Fig. 171).

FIG. 171.

The most important species of this family is the Red-bug, or Cotton-stainer, *Dysdercus suturellus* (Dys-der'cus su-tu-rel'lus) (Fig. 172). The adult is of a reddish color; the wing-covers are pale brown, with pale-yellow stripes. The young are bright red, with black legs. They do much damage by piercing the stems and bolls of the cotton-plant and sucking the juices, but do much more damage by staining the cotton in the opening bolls. They also puncture the rind of oranges in Florida, so that decay soon sets in, and the fruit drops. These insects can be trapped by laying chips of sugar-cane around the cotton-

FIG. 172.—*Dysdercus suturellus*

fields. In orange-groves heaps of cotton-seed as well as pieces of sugar-cane will be found useful; the insects will collect in these places and can be scalded to death.

Family LYGÆIDÆ (Ly-gæ'i-dæ).

The Chinch-bug Family.

This, too, is a large family, about one hundred and fifty species being known to occur in the United States. Here the membrane of the wing-covers is furnished with four or five simple veins, which arise from the base of the membrane; sometimes the two inner veins are joined to a cell near the base (Fig. 173).

FIG. 173.

This family contains the Chinch-bug, *Blissus leucopterus* (Blis'sus leu-cop'te-rus), the most destructive member of the Heteroptera occurring in the United States. Although quite widely distributed, its injuries have attracted most attention in the Mississippi Valley, where it has destroyed many million dollars' worth of grain. It is a small bug, measuring less than one sixth of an inch in length. In Figure 174 it is represented slightly enlarged and greatly enlarged. It is blackish in color, with snowy-white wing-covers, each marked with a dark spot and Y-shaped line, as shown in the figure. The species is dimorphic, there being a short-winged form.

FIG. 174.—*Blissus leucopterus.*

There are two generations of the Chinch-bug each year; they winter as full-grown insects and hide under rubbish. In the early spring they come forth and lay their eggs in fields of grain upon the roots or stems beneath the ground. The eggs hatch in about two weeks. The nymphs are red, and feed at first upon roots; afterwards they attack the stalks of the plants they infest. In about fifty days they get their growth. About this time the whole brood starts out to find new pastures, and they all march on foot in one direction, like an army. Although they are tiny insects they

number millions, and so attract much attention. As soon as they find a new field of grain they lay their eggs there for another brood.

No satisfactory means of combating this insect was known until recently. But it has now been ascertained that it is destroyed by a contagious disease which can be spread artificially. Diseased bugs are sent to places where the disease does not exist; and thus the contagion is spread. Extensive experiments are being carried on in Kansas at the time of this writing, and the results so far seem very encouraging.

Family BERYTIDÆ (Be-ryt′i-dæ).

The Stilt-bugs.

This family includes a small number of land bugs, in which the body, legs, and antennæ are very slender, resembling somewhat the thread-legged bugs (Emesidæ).

FIG. 175.—*Jalysus spinosus.*

The stilt bugs have the tip of the femora, the tip of the first joint of the antennæ, and the last joint of the antennæ somewhat enlarged (Fig. 175). Only two species have been found in the United States. These are *Neides muticus* (Ne′i-des mu′ti-cus), which has a prominent spine on the vertex of the head; and *Jalysus spinosus* (Jal′y-sus spi-no′sus), which, although spined in other places, lacks the spine on the vertex.

These are sluggish insects, found in the undergrowth of woods and in meadows and pastures.

Family COREIDÆ (Co-re′i-dæ).

The Squash-bug Family.

This family is also a very extensive one, including many species. The best character for distinguishing the members

of it is the nature of the venation of the membrane of the wing-covers. This part is furnished with many veins, most of which spring from a cross-vein near its base (Fig. 176).

Fig. 176.

The Squash-bug, *Anasa tristis* (An'a-sa tris'-tis), is a good example of this great family. These when full-grown are brownish-black bugs, with some yellow spots along the edges of the abdomen (Fig. 177), and are dirty yellow on the under side. This bug winters in the adult state, and takes the first opportunity in the spring to lay its eggs on the earliest sprouts of squash and pumpkin vines. As soon as they hatch, the young bugs attack the vines and are apt to destroy them entirely. The remedy is to protect the young plants by frames covered with netting.

Fig. 177.—*Anasa tristis.*

Family Pentatomidæ (Pen-ta-tom'i-dæ).

The Stink-bug Family.

This is a family the taste and odor of which most of us know to our sorrow. We learn the flavor in one experience, and conclude that once is enough for a lifetime. To those who live in cities it may always remain a mystery why one berry looking just like another should taste and smell so differently; but all barefooted boys and sun-bonneted girls from the country who have picked the wild strawberries on the hillsides or scratched their hands and faces in raspberry patches know well the angular green or brown bugs that leave a loathsome trail behind them; and they will tell you, too, that the bugs themselves are worse than their trail, for it is a lucky youngster that has not taken one of these insects into his mouth by mistake with a handful of berries.

It should not be concluded, however, that only members of this family possess this disagreeable odor; for most of the Heteroptera protect themselves by rendering their bodies unpalatable in this way. Doubtless birds soon learn this

fact and leave such bugs alone. But it is to members of this family that the expressive name given above is commonly applied.

This nauseous odor is caused by a fluid which is excreted through two openings, one on each side of the lower side of the body near the middle coxæ.

In this family the antennæ are five-jointed; the scutellum, although large, is less than half as long as the abdomen; and the front legs are not fitted for digging (Fig. 178).

FIG. 178. — A Stink-bug.

Some species of this family feed upon other insects, and so are very helpful to the farmer, one species especially being a gallant fighter against the potato-beetle. Other species feed entirely upon vegetables, while others live upon both vegetable and animal matter.

The Harlequin Cabbage-bug or Calico-back, *Murgantia histronica* (Mur-gan'ti-a his-tron'i-ca), is very destructive to cabbages, radishes, and turnips in the Southern States and on the Pacific coast. It is black with bands, stripes, and margins of red or orange or yellow. The full-grown bugs live through the winter, and in the early spring each female lays on the under surface of the young leaves about twelve eggs in two parallel rows. The young bugs are pale green, with black spots. They mature in a few days, so there are many generations in one season. It is difficult to find a remedy for this pest, but much can be done by placing cabbage and turnip leaves on the ground in early spring, and thus trapping them when they first come out of their winter quarters.

Family CYDNIDÆ (Cyd'ni-dæ).

The Burrower-bugs.

These are oval, rounded, or elliptical bugs, with five-jointed antennæ; with the scutellum large, but less than

half as long as the abdomen; and with the front legs more or less flattened, fitted for digging (Fig. 179).

FIG. 179.—*Cyrtomenus mirabilis.*

The species are generally black or very dark brown. They are found burrowing in sandy places, or on the surface of the ground beneath sticks and stones, or at the roots of grass and other herbage. The family is not a large one. The members of it probably feed upon plants; but it is desirable that further observation be made upon the habits of this family.

Family CORIMELÆNIDÆ (Cor-i-me-læn'i-dæ).

The Negro-bugs.

These bugs are mostly black, and are beetle-like in appearance; some have a bluish or greenish tinge, and all are very convex. The scutellum is very convex, and, as in the following family, covers nearly the whole of the abdomen. But in this family there is at the base of the scutellum on each side a short furrow into which the edge of the wing-cover fits when at rest. All of our species belong to the genus *Corimelæna* (Cor-i-me-læ'na).

FIG. 180.—*Corimelæna atra.*

These insects infest various plants, and often injure raspberries and other fruit by imparting a disagreeable odor to them. Fig. 180 represents one of these bugs, somewhat enlarged.

Family SCUTELLERIDÆ (Scu-tel-ler'i-dæ).

The Shield-backed Bugs.

The members of this family resemble the negro-bugs in the shape and size of the scutellum, which covers nearly the whole of the abdomen; but the sides of the scutellum are not furnished with a groove for receiving the edge of the wing-covers. Fig. 181 represents one of these insects enlarged. They feed upon plants.

FIG. 181.—*Eurygaster alternatus.*

Suborder PARASITA (Par-a-si'ta).

The Parasita includes certain parasites of man and other mammals, commonly known as lice. They are wingless, and differ from other Hemiptera in having the beak fleshy and not jointed. This suborder is represented in the United States by only one family, the *Pediculidæ*.

Family PEDICULIDÆ (Ped-i-cu'li-dæ).

The Lice.

This family comprises the true lice, which differ from the bird-lice of the order Mallophaga in having sucking mouth-parts. The true lice live on the skin of mammals, and suck their blood.

There are three species that infest man: one living on the head, among the hair; and the other two on the body. Several species infest our domestic animals. The more

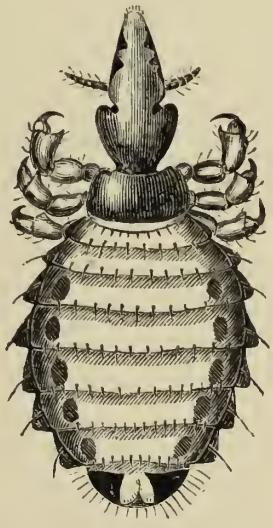

FIG. 182.—*Hæmatopinus asini.* (From Law.)

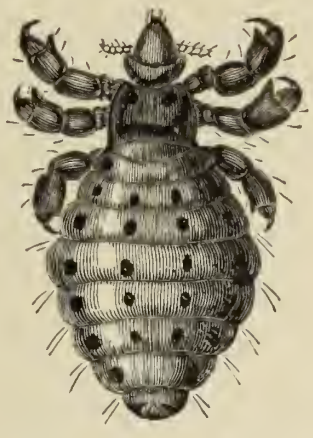

FIG. 183.—*H. eurysternus.* (From Law.)

common of these are the louse of the horse (Fig. 182), and the louse of the cow (Fig. 183).

Various substances are used for destroying lice on domestic animals: among them are a strong infusion of tobacco,

an ointment made of one part sulphur and four parts lard, Scotch snuff, powdered wood ashes, and kerosene emulsion.

The remedy should be applied thoroughly, and repeated several times at intervals of three or four days, in order to destroy the young which may hatch after the first application. The stable and the places where the cattle are in the habit of rubbing should also be whitewashed or sprayed with kerosene, or strong kerosene emulsion.

Suborder HOMOPTERA (Ho-mop'te-ra).

Cicadas, Leaf-hoppers, Aphids, Scale-bugs and others.

The Homoptera includes insects of widely diversified form, but which agree, however, in having the wings when present of the same thickness throughout, and usually sloping roof-like at the sides of the body when at rest, and in having the beak arise from the hinder part of the lower side of the head (Fig. 140, *b*). The name is from two Greek words: *homos*, same; and *pteron*, a wing.

This suborder includes nine families, which are designated as follows:

The Cicadas, Family CICADIDÆ (p. 149).
The Lantern-fly Family, Family FULGORIDÆ (p. 151).
The Spittle Insects, Family CERCOPIDÆ (p. 152).
The Leaf-hoppers, Family JASSIDÆ (p. 153).
The Tree-hoppers, Family MEMBRACIDÆ (p. 154).
The Jumping Plant-lice, Family PSYLLIDÆ (p. 155).
The Plant-lice, Family APHIDIDÆ (p. 156).
The Aleyrodes, Family ALEYRODIDÆ (p. 163).
The Scale-bugs, Family COCCIDÆ (p. 164).

CLASSIFICATION OF THE HOMOPTERA.

(*For advanced students.*)

TABLE FOR DETERMINING THE FAMILIES OF THE HOMOPTERA.

A. Beak evidently arising from the head; tarsi three-jointed; antennæ minute, bristle-like.

B. With three ocelli, and the males with musical organs. Usually large insects, with all the wings entirely membranous. p. 149. CICADIDÆ.

BB. Ocelli only two in number or wanting; males without musical organs.

C. Antennæ inserted on the sides of the cheeks beneath the eyes. p. 151. FULGORIDÆ.

CC. Antennæ inserted in front of and between the eyes.

D. Prothorax not prolonged above the abdomen.

E. Hind tibiæ armed with one or two stout teeth, and the tip crowned with short stout spines p. 152. CERCOPIDÆ.

EE. Hind tibiæ having a row of spines below p. 153. JASSIDÆ.

DD. Prothorax prolonged into a horn or point above the abdomen. p. 154. MEMBRACIDÆ.

AA. Beak apparently arising from between the front legs, or absent; tarsi one or two jointed; antennæ usually prominent and thread-like, sometimes wanting.

B. Tarsi usually two-jointed; wings when present four in number.

C. Wings transparent.

D. Hind legs fitted for leaping; antennæ nine or ten jointed. p. 155. PSYLLIDÆ.

D. Legs long and slender, not fitted for leaping; antennæ three to seven jointed. p. 156. APHIDIDÆ.

CC. Wings opaque, whitish; wings and body covered with a whitish powder. p. 163. ALEYRODIDÆ.

BB. Tarsi one-jointed; adult male without any beak, and with only two wings; female wingless, with the body either scale-like or gall-like in form, or grub-like and clothed with wax. The waxy covering may be in the form of powder, of large tufts or plates, of a continuous layer, or of a thin scale beneath which the insect lives. p. 164. COCCIDÆ.

Family CICADIDÆ (Ci-cad'i-dæ).

The Cicadas (*Ci-ca'das*).

The large size and well-known songs of the more common species of this family render them familiar objects. It is only necessary to refer to the Periodical Cicada (or the seventeen-year locust, as it has been improperly termed) and to the

Dog-day Harvest-fly (Fig. 184) to give an idea of the more striking characters of this family. We have several species much smaller than either of these; but their characteristic form and the presence of three ocelli are sufficient to distinguish them from the members of the other families.

FIG. 184.—*Cicada tibicen.*

The Periodical Cicada, *Cicada septendecim* (Ci-ca'da sep-ten'de-cim), is very generally known in this country, owing to the great numbers in which it appears, at long intervals of time. This periodical appearance is due to the long time required for the nymphs to obtain their growth—either seventeen or thirteen years—and to the fact that all the members of one generation appear in the adult state at about the same time. The adult female lays her eggs in slits which she makes in the twigs of trees. Small fruit is sometimes injured in this way. The eggs hatch in about six weeks. The young nymphs finding no attraction in a world of sunshine and of flowers, drop to the ground and bury themselves in the earth, thus commencing a voluntary seclusion which lasts for years. They live by sucking the juices from the roots of trees. In May of the seventeenth year after their retirement to their earthy cloisters they crawl up to the surface of the ground, like renegade monks; and, leaving their nymph-skins clinging to the tree-trunks, like cast-off garments of penance, they come forth, broad-headed, broad-bodied, clear-winged creatures, well fitted to get all the experience possible out of a world whose frivolities they have so long scorned. But, like other creatures, they find a life of dissipation very exhausting, and after a few weeks they sing their last song, lay their eggs, and pass away.

In the South these insects live only thirteen years under

ground, but in the North it requires seventeen years for a nymph to reach maturity.

More than twenty distinct broods of this species have been traced out. In many localities several broods coexist; this explains the fact that in such places these insects appear several times during a single period of seventeen years.

There is a common species of Cicada known as the Dog-day Harvest-fly or Lyreman, *Cicada tibicen* (Ci-ca'da ti-bi'cen), which requires only two years for its development, and as there are two broods of this species the adults appear every year. This Cicada (Fig. 184) is black and green in color, and more or less powdered beneath. And its song is the high, sharp trill that comes to us, midsummer noons, from the depths of trees where the singer is hidden amid the foliage, all unconscious that its shrill note has for centuries been a theme for poets.

Family FULGORIDÆ (Ful-gor'i-dæ).

The Lantern-fly Family.

This family is remarkable for certain exotic forms which it contains. Chief among these is the great Lantern-fly of Brazil, which is figured in many popular works on insects. Scarcely less strange are the Candle-flies of China and the East Indies. The popular names of these insects refer to the fact that they are phosphorescent, but we know of no native species that possesses this peculiarity. There does not seem to be any typical form of the body characteristic of this family. The different genera differ so greatly, that on superficial examination they appear to have very little in common. Some even resemble butterflies and moths, while others might easily be mistaken for neuropterous genera.

The most useful character for recognizing these insects is the form and position of the antennæ. These are bristle-shaped, and inserted in a button-shaped base on the side of

the cheek beneath the eyes. Although the Fulgoridæ are vegetable feeders, none of our species have attracted the attention of agriculturists. There are, however, certain exotic species which do great injury to crops.

The two accompanying figures will serve to show the wonderful variations in form of these insects; many other types exist. Figure 185 represents a common species of *Scolops* (Sco'lops), which occurs in grassy places. In this genus the head is greatly prolonged, as with the exotic Candle-flies.

FIG. 185.—*Scolops.*

FIG. 186.—*Ormenis septentrionalis.*

Figure 186 represents *Ormenis septentrionalis* (Or'me-nis sep-ten-tri-o-na'lis), a beautiful pale-green species powdered with white, which feeds on wild grape-vines, drawing nourishment from the tender shoots and mid-ribs of the leaves during its young stages.

Family CERCOPIDÆ (Cer-cop'i-dæ).

The Spittle Insects or Frog-hoppers.

During the summer months one often finds upon various shrubs and herbs masses of white froth. In the midst of each of these masses there lives a young insect, a member of this family. In some cases as many as four or five insects inhabit the same mass of foam. The froth is supposed to consist of sap, which the insect has pumped from the plant, by means of its beak, and passed through its alimentary canal. It is asserted that these insects undergo all their transformations within this mass; that when one is about to molt for the last time, a clear space is formed about its body; the superficial part of the foam dries, so as to form a vaulted roof to a closed chamber, within which the change

of the skin is made. The adult insects wander about on herbage and trees. They have the power of leaping well. The name frog-hoppers has doubtless grown out of the fact that formerly the froth was called "frog-spittle," and was supposed to have been voided by tree-frogs from their mouths. The name is not, however, inappropriate, for the broad and depressed form of our more common species is something like that of a frog.

In this family the antennæ are inserted in front of and between the eyes; the prothorax is not prolonged back of the abdomen (as in the Membracidæ); and the tibiæ are armed with one or two stout teeth, and the tip crowned with short, stout spines, as shown in Figure 187. This figure represents the most common spittle insect of the Eastern United States, *Aphrophora quadrangularis* (A-phroph'o-ra quad-ran-gu-la'ris), and one of its tibiæ greatly enlarged.

FIG. 187.—*Aphrophora quadrangularis.*

Family JASSIDÆ (Jas'si-dæ).

The Leaf-hoppers.

The most abundant members of the Homoptera, except perhaps the Aphids, are the leaf-hoppers. Large numbers of them can be easily collected by sweeping grass, herbage, or the foliage of shrubs.

The leaf-hoppers are more slender than the spittle insects, and are also distinguished by the form of the hind tibiæ, which are nearly or quite as long as the abdomen, curved, and armed with a row of spines on each margin (Fig. 188).

FIG. 188.—*Proconia undata.*

Among the leaf-hoppers that have attracted attention on account of their injuries to vegetation are the following: The destructive Leaf-hopper, *Cicadula exitiosa* (Ci-cad'u-la ex-it-i-o'sa), which is represented greatly enlarged by Figure 189, sometimes infests winter wheat to a serious extent in the Southern States. The Grape-

FIG. 189. — *Cicadula exitiosa.* (From the Author's Report for 1879.)

vine Leaf-hopper, *Erythroneura vitis* (E-ryth-ro-neu'ra vi'tis), is a well-known pest that infests the leaves of the grape. It is about one-eighth inch in length, crossed by two blood-red bands, and a third dusky one at the apex. It is often improperly called the "Thrip" by grape-growers. But the term Thrip or better Thrips should be restricted to members of the order Physopoda. The Rose Leaf-hopper, *Empoa rosæ* (Em'po-a ro'sæ), is also a well-known pest, as it often swarms on the leaves of roses, doing great damage. Its presence is usually indicated by numerous white cast skins adhering to the lower side of the leaves.

The leaf-hoppers can be destroyed by a strong solution of soap, or with kerosene emulsion. In vineyards, where the use of these substances would injure the fruit, they can be trapped by two persons carrying a screen covered with tarred paper on one side of a row of vines, while a third person walking on the other side of the row frightens them from the vines on to the screen. Dead leaves and other rubbish, among which these insects hibernate, should be burned during the winter.

Family MEMBRACIDÆ (Mem-brac'i-dæ).

The Tree-hoppers.

Nature must have been in a joking mood when tree-hoppers were developed, for these little creatures are most

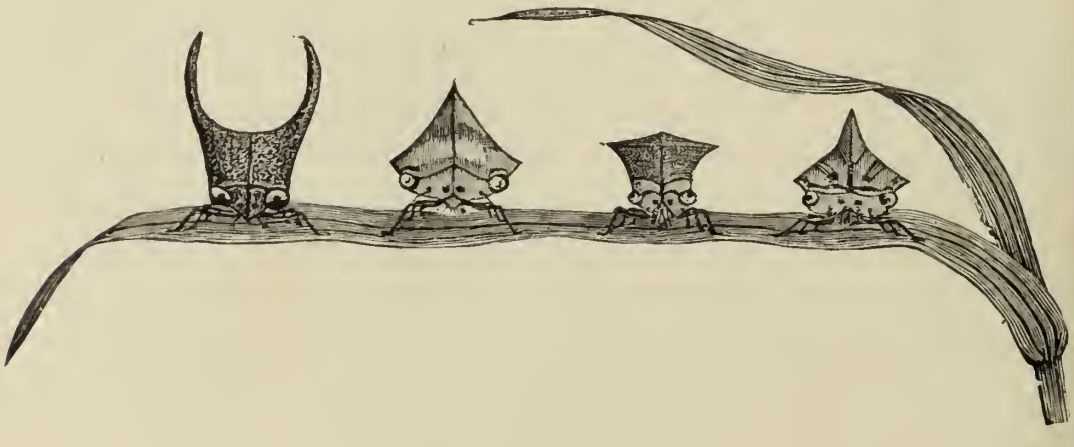

FIG. 190.—Tree-hoppers.

comically grotesque in appearance. In general outline they resemble beech-nuts, except that many have humps on their backs. The prothorax is prolonged backward like a roof over the body, often quite covering it. If the young entomologist wishes to laugh, let him look at the faces of tree-hoppers through a lens (Fig. 190). Their eyes always have a keen, droll look, and the line that separates the head from the prothorax gives them the appearance of wearing glasses. In some cases the prothorax is elevated above the head, so that it looks like a peaked nightcap; in others it is shaped like a Tam-o'-Shanter; and sometimes it has horns, one on each side, which have given one species the name of the Buffalo Tree-hopper.

FIG. 192.—*Ceresa bubalus.*

FIG. 193.—*Enchenopa binotata.*

Many species of this family live upon bushes or small trees, and are all good leapers; hence the common name, Tree-hoppers. Some species excrete honey-dew, and are attended by ants. All feed upon plants, but they seldom appear in sufficient numbers to do much damage.

FIG. 194.—*Telamona.*

The accompanying figures will show some of the more common forms seen in this strange family (Figs. 191–194).

Family PSYLLIDÆ (Psyl'li-dæ).

The Jumping Plant-lice.

The jumping plant-lice are comparatively small insects; our more common species measuring only from one-eighth to one-sixth inch in length, and it is rare that we find any twice that size. When examined with a lens they appear like tiny Cicadas (Fig. 195). Their hind legs are formed for jumping; their antennæ are nine or ten jointed, and their tarsi are only two-jointed. Figure 197 represents the wings of a common species.

FIG. 195.—Psylla, enlarged.

The Psyllidæ subsist entirely upon the

juices of plants, and some of them cause serious injuries. Many species form galls; one of the larger of these infest the Celtis or Hackberry.

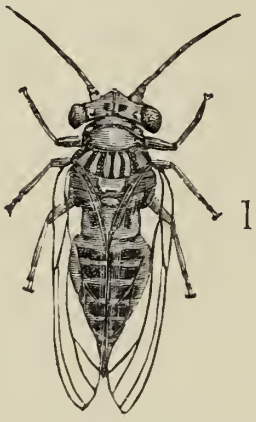

FIG. 196.—The Pea-rtree Psylla, greatly enlarged.

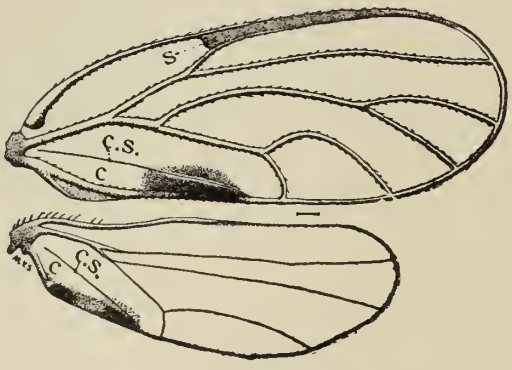

FIG. 197.—Venation of Wings: *s*, stigma; *c*, clavus; *c. s.*, claval suture.

The most destructive member of this family in the United States is the Pear-tree Psylla, *Psylla pyricola* (Psyl'la py-ric'o-la). This is a minute species, measuring only one-tenth inch in length to the tip of the folded wings (Fig. 196). But it occurs in such large numbers that it has destroyed extensive pear orchards, by sucking the sap from the smaller limbs and twigs. It can be destroyed by spraying the infested trees with kerosene emulsion immediately after the leaves have expanded in the spring.

Family APHIDIDÆ (A-phid'i-dæ).

The Plant-lice or Aphids (*Aph'ids*).

The plant-lice are well-known insects; they infest nearly all kinds of vegetation in all parts of the country. Our most common examples are minute, soft-bodied, green insects, with long legs and antennæ, which appear on various plants in the house and in the field. Among our common species are both winged and wingless forms (Fig. 198). There are a great number of species, nearly all of

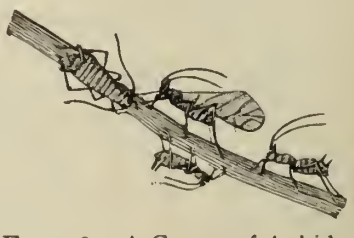

FIG. 198.—A Group of Aphids.

which are of small size. In our largest species the body measures only about one-fourth inch in length, and usually these insects are very much smaller.

The body is usually more or less pear-shaped. The winged forms have two pairs of delicate, transparent wings. These are furnished with a few simple veins, but the venation is more extended than in either of the two following families. The first pair of wings is larger than the other, and the two wings of each side are usually connected by a compound hooklet. The beak is three-jointed, and varies greatly in length; sometimes it is longer than the body. The compound eyes are prominent, and ocelli are also usually present. The antennæ are from three to seven jointed. On the back of the sixth abdominal segment there is, in many species, a pair of tubes, through which a sweet, transparent fluid is excreted. In some genera these organs are merely perforated tubercles, while in still other genera they are wanting.

The fluid which is excreted through the abdominal tubercles is the substance known as honey-dew. It is sometimes produced in such quantities that it forms a glistening coating on the leaves of the branches below the plant-lice, and stone walks beneath shade-trees are often densely spotted with it. This honey-dew is fed upon by bees, wasps, and ants. The bees and wasps take the food where they find it, paying little if any attention to its source; but the ants recognize in the plant-lice useful auxiliaries, and often care for them as men care for their herds. This curious relationship will be discussed farther under the head of Ants.

It is easy to see what benefit ants derive from this association with plant-lice, and how they should learn that it is worth while for them to care for their herds of honey-producing cattle. Little has been done, however, to point out the great benefit that accrues to the plant-lice from this relationship. It seems fair to assume that the plant-lice are greatly benefited, else why has the highly specialized appa-

ratus for producing the honey-dew been developed? Writers long ago showed that ants protect plant-lice by driving away from them lady-bugs and other enemies. Recently, however, Professor Forbes has demonstrated that, in certain cases at least, a more important service is rendered. In his studies of the Corn Plant-louse, *Aphis maidis* (A'phis mai'dis), he found that this species winters in the wingless, agamic form in the earth of previously infested corn-fields, and that in the spring the plant-lice are strictly dependent upon a species of ant, *Lasius alienus* (Las'i-us al-i-e'nus), which mines along the principal roots of the corn, collects the plant-lice, and conveys them into these burrows, and there watches and protects them. Without the aid of these ants, the plant-lice were unable to reach the roots of the corn.

In addition to honey-dew, many Aphids excrete a white substance. This may be in the form of powder, scattered over the surface of the body, or it may be in large flocculent or downy masses; every gradation between these forms exists.

The plant-lice are remarkable for their peculiar mode of development. The various species differ greatly in the details of their transformation, but the following generalizations can be made.

There are several distinct forms in each species, each form playing a peculiar part in the history of the species. If a colony of plant-lice be examined during the summer months it will be found, usually, to consist very largely of wingless individuals; these are females, which reproduce without the intervention of males. This is the *wingless agamic form.* In many cases this form gives birth to living young, instead of laying eggs; and the reproduction of this form is so rapid, that it would be disastrous to the species, by the destruction of the infested plants and the consequent starving of the insects, if another form of the species did not arise. But from time to time young are produced which become winged, and thus the spread of

the species is provided for. This winged form also consists entirely of females, and is known as the *winged agamic form.* They produce in turn the wingless agamic form, a single, winged individual, which has flown to a new plant, starting a new colony. Generally on the setting in of cold weather, or in some cases on the failure of nourishment, the weather being still warm, there is produced a generation including individuals of both sexes. These are known as the *sexual forms.* The *males* may be either winged or wingless, but these *true females* are always wingless. The sexual forms pair, and the female produces one or more true eggs. It is in this state that the species usually pass the winter, and consequently these eggs produced by the sexual form are often called the *winter eggs*, to distinguish them from egg-like bodies produced by the agamic forms of certain species, and which are termed *pseudova* (pseu-do'va). From the winter egg there hatches, usually in the spring, an agamic female, which, as she is the stock from which the summer generations spring, is often called the *stem-mother.* The peculiar reproduction of the agamic forms is often termed reproduction by *budding.*

Plant-lice are often very destructive to vegetation. The ordinary methods of combating them are either by the use of a strong solution of soap or with kerosene emulsion.

Plant-lice vary greatly in their habits. Certain species live in the ground on the roots of plants. The Lettuce Earth-louse, *Rhizobius lactucæ* (Rhi-zo'bi-us lac-tu'cæ), is a good illustration. This occurs on the roots of lettuce, often in great numbers. Other species are found on the roots of grasses or herbaceous plants and usually accompanied by ants.

On the other hand, many species, in fact the majority of Aphids, pass their lives on the foliage of plants, infesting especially the tenderer leaves. Familiar examples are the Cabbage Aphis, *Aphis brassicæ* (A'phis bras'si-cæ), the Apple-tree Aphis, *Aphis mali*, the Cherry-tree Aphis, *Mysus cerasi* (My'sus cer'a-si), and the Peach-tree Aphis, *Mysus persicæ*

(My'sus per'si-cæ). The last three are almost invariably attended by ants.

The Plant-lice of the genus *Lachnus* (Lach'nus) are usually found on the limbs of trees and shrubs. To this genus belong our largest Aphids, some of them measuring one-fourth inch in length. Figure 199 represents one of these enlarged

FIG. 199.—*Lachnus.*

Some species of plant-lice live both on the roots and on the leaves of plants. One of these is the Grape Phylloxera, *Phylloxera vastatrix* (Phyl-lox-e'ra vas-ta'trix), which is the most important enemy of the grape. The presence of this insect is manifested by the vines in two ways: first, in the case of certain species of grapes, there appear upon the lower surface of the leaves fleshy swellings, which are more or less wrinkled and hairy; these are hollow galls, opening upon the upper surface of the leaf, and containing a wingless agamic plant-louse and her eggs; second, when the fibrous roots of a sickly vine are examined, we find, if the disease is due to this insect, that the minute fibres have become swollen and knotty; or, if the disease is far advanced, they may be entirely decayed. Upon these root-swellings we also find an agamic, wingless, egg-laying plant-louse, the author of the mischief. The insects found upon the roots differ slightly from those found within the galls, but their specific identity is now generally accepted.

Owing to the great injury which this species has done to the vineyards of France, hundreds of memoirs have been published regarding it. But as yet no satisfactory means of destroying it has been discovered. The difficulty lies in the fact that the insecticide must be one that can penetrate the ground to the depth of three or four feet, reaching all the fibrous roots infested by the insect. It must be a substance that can be cheaply applied on a large scale, and it must also be something that will kill the insect without injury to

the vine. Carbon bisulphide has been used to some extent for this purpose.

Where the vineyards are so situated that they can be submerged for a period of at least forty days during the winter, the insect can be drowned. But this method is obviously of limited application.

It is found that vines growing in very sandy soil resist the attacks of the Grape Phylloxera. This is supposed to be due to the difficulty experienced by the insect in finding passage through such soil.

Another well-known example of the plant-lice that make galls is *Colopha ulmicola* (Col′o-pha ul-mic′o-la), which makes the Cockscomb Elm-gall. This gall is shaped more or less like a cock's comb, and is very common on the upper side of the leaves of the elm.

There is a group of species of plant-lice known as the Woolly Aphids, on account of a white more or less downy or waxy substance with which the bodies of these insects are covered. Large numbers of one of these species are often found crowded together on the under side of the branches of alder. This species is known as the Alder-blight, *Schizoneura tessellata* (Schiz-o-neu′ra tes-sel-la′ta). In addition to the white excretion with which the body is covered this insect excretes large quantities of honey-dew. The result is that the branches infested by this insect, and those beneath the clusters of Aphids, become blackened with fungi that grow upon this secretion. There is also a curious fungus which grows in large spongy masses immediately beneath the clusters of plant-lice; this is known to botanists as *Scorias spongiosum.* It is evidently fed by the honey-dew that falls upon it.

The Beech-tree Blight, *Schizoneura imbricator* (im-bri-ca′tor), infests both the twigs and leaves of beech. Like the preceding species it occurs in clusters of individuals, each of which is clothed with a conspicuous downy excretion. These clusters often attract attention by the curious

habit that the insects have of waving their bodies up and down, the plume-like masses of excretion rendering them very conspicuous. When an infested limb is jarred the Aphids emit a shower of honey-dew. Owing to the abun dance of this secretion, the branches and leaves of an infested tree become blackened by growths of fungi, as with the preceding species.

The Woolly-louse of the Apple, *Schizoneura lanigera* (la-nig'e-ra), is one of the best-known pests of the fruit-grower. In its most conspicuous form it appears on the trunks and limbs of apple-trees, in clusters of individuals, which are conspicuous on account of the woolly excretion with which the bodies are covered. It is especially injurious to young trees, the bark of which becomes deeply pitted and scarred by its attacks. The bark apparently ceases to grow at the point of attack, but swells into a large ridge about the cluster of lice, leaving them in a sheltered pit. The lice also frequently congregate in the axils of the leaves and the forks of the branches. This species resembles the Grape Phylloxera in having a root-inhabiting form, which causes knotty swellings on the fibrous roots. It is the presence of this form that makes this pest such a difficult one to combat. For as it works deep in the ground upon the fibrous roots of trees, the same difficulties are met in attempting to destroy it that are presented by the Grape Phylloxera. In fact, except in case of an especially valuable tree, we do not believe that it will pay to attempt to save a tree that has become badly infested by the woolly aphis. It will be cheaper to dig the tree up and burn it, and devote the ground to some other use. Another species of tree can be safely planted in the same place, but not an apple. Great care should be taken in putting out trees from a nursery to see that they are free from this pest. If there is any doubt the trees should be washed, roots and all, in a strong solution of soap. It is well also to put in the forks of the trees pieces of hard soap, which will

be dissolved and washed down by the rains. This will serve to destroy certain other pests, as well as the woolly aphis. In case it is desired to rid an infested tree of this pest, the trunk form should be washed off with a strong solution of soap applied with a sponge, taking care to destroy all eggs; and the ground should be treated with carbon bisulphide, as for the Grape Phylloxera.

Family ALEYRODIDÆ (Al-eu-rod'i-dæ).

The Aleyrodes (*Al-eu-ro'des*).

The insects of the genus *Aleyrodes* were for a long time classed with the Coccidæ. In their immature state they are scale-like in form (Fig. 200), and often somewhat resemble certain species of Lecanium. But the mature insects differ so much from the Coccids that the genus has been separated as a distinct family. They are very small insects; the species with which I am acquainted have an expanse of wings of about one eighth of an inch. Both sexes are winged; and, as with other Hemiptera except the Coccids, there are two pairs of wings. In the adult state, all the species are nearly of the same color; the wings are white, sometimes spotted; the body is usually yellowish, sometimes pinkish, and more or less spotted with black. The most striking character presented by the adults, in addition to the fact that both sexes are winged and each has two pairs of wings, is the presence of a whitish powder with which the wings and body are covered. It is this character that suggests the name of the genus, which is from the Greek *aleurodes*, like flour.

FIG. 200.—*Aleyrodes*

Family Coccidæ (Coc'ci-dæ).

The Scale-bugs or Bark-lice, Mealy-bugs, and others.

The family Coccidæ includes the Mealy-bugs, the Scale-bugs or Bark-lice, and certain other insects for which there are no popular names. In this family we find those members of the Hemiptera that depart most widely from the type of the order. In fact this is a very anomalous group, the species differing greatly in appearance, habits, and metamorphoses from those of the most closely allied families. Not only do the members of this family appear very unlike other insects, but there is a wonderful variety of forms within the family, and even the two sexes of the same species differ as much in the adult state as members of distinct orders.

The males of Coccidæ, unlike all other Hemiptera, undergo a complete metamorphosis. The adult males have only a single pair of wings, the hind wings being represented by a pair of club-like halteres. Each of these is furnished with a bristle, which in all the species we have studied is hooked, and fits in a pocket on the wing of the same side (Fig. 202). The male in the adult state has no organs for procuring food, as the mouth-parts disappear during the metamorphosis of the insect, and a second pair of eyes appear in their place. The adult female is always wingless, and the body is either scale-like or gall-like in form, or grub-like and clothed with wax. The waxy covering may be in the form of powder, of large tufts or plates, of a continuous layer, or of a thin scale, beneath which the insect lives.

Among the Coccidæ are found many of the most serious pests of horticulturists. Scarcely any kind of fruit is free from their attacks, and certain species of scale-insects and mealy-bugs are constant pests in conservatories. The ease with which these insects or their eggs can be transported long distances while yet alive, on fruit or living plants, has

caused many species that infest cultivated plants to become world-wide in distribution.

During recent years much attention has been paid to devising methods of destroying these pests. Various soapy

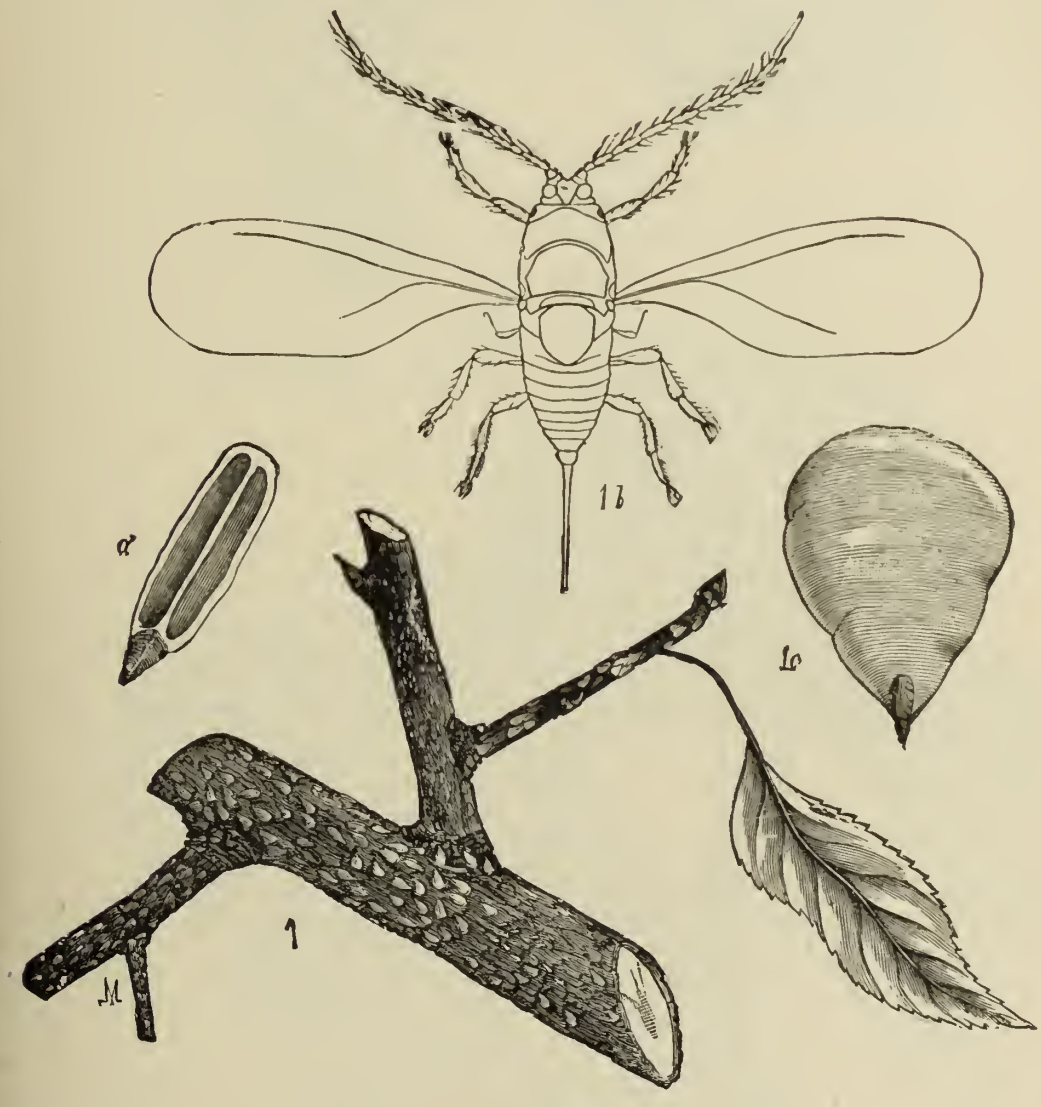

FIG. 202.—The Scurfy Bark-louse. *Chionaspis furfurus:* 1, scales natural size; 1*a*, scale of male enlarged; 1*b*, adult male enlarged; 1*c*, scale of female enlarged.

or alkaline washes, and one made of lime, salt, and sulphur, are now used on the trees with deciduous foliage; the wash is applied during the winter while the trees are naked. In the case of orange and lemon trees, which are constantly clothed with leaves, a large tent is lowered over the tree and a

poisonous gas (hydrocyanic-acid gas) is generated within the tent.

A number of useful insects belong to this family. Several species furnish dye-stuffs. The best known of these is *Coccus cacti*, the dried bodies of which are known as Cochineal. The stick lac of commerce, from which shell-lac or shellac is prepared, is a resinous substance excreted by a species, *Carteria lacca* (Car-ter'i-a lac'ca), which lives on the young branches of several tropical trees, and the bodies of these insects, which are obtained from the stick lac, furnish the coloring agents known as lac dye. China wax is another substance for which we are indebted to this family. It is the excretion of an insect known as Pe-la, *Ericerus pe-la* (E-ri-ce'rus). In fact many species of this family excrete wax in considerable quantities.

Among the more prominent members of this family are the following:

The Cottony-cushion Scale, *Icerya purchasi* (I-ce'ry-a pur'cha-si).—This beautiful insect (Fig. 203) was at one time the most dangerous insect pest in California, and did a great amount of injury. It is an introduced Australian species, and has been subdued to a great extent by the introduction of an Australian Lady-bug, *Vedalia* (Ve-da'li-a), which preys upon it. The body of the adult female is scale-like, dark orange-red, and has the dorsal surface more or less covered with a white or yellowish-white powder. The insect secretes a large egg-sac, which is beautifully ribbed.

FIG. 203.—*Icerya purchasi*. Females, adult and young, on orange. (From the Author's Report for 1880.)

The Mealy-bugs, *Dactylopius* (Dac-ty-lo'pi-us).—The

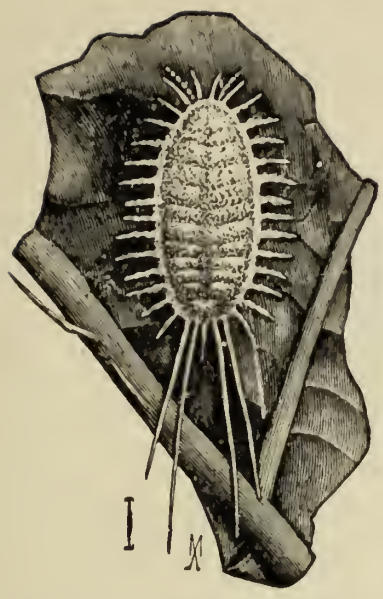

FIG. 204.—*Dactylopius longispinus*, female, enlarged. (From the Author's Report for 1880.)

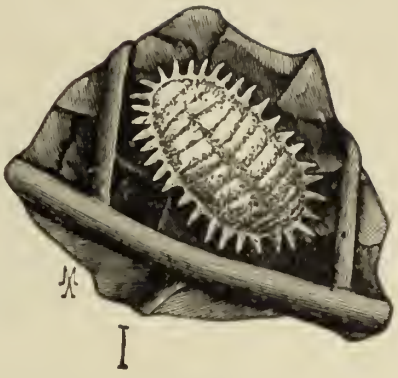

FIG. 205.—*Dactylopius citri*, female, enlarged. (From the Author's Report for 1880.)

FIG. 206.—*Kermes* sp., on *Quercus agrifolia*. Adult females on stem; immature males on leaves. (From the Author's Report for 1880.)

Mealy Bugs are the most common and the most noxious of green-house pests; and in the warmer regions, as in Florida, they infest plants in the open air. Two species are shown greatly enlarged in Figures 204 and 205. These insects are extremely difficult to combat, as the white powder with which the body is clothed protects them from the sprays and washes ordinarily used.

Kermes.—Species of this genus are common upon oaks wherever they grow. These insects are remarkable for the wonderful gall-like form of the adult females. So striking is this resemblance, that they have been mistaken for galls by many entomologists. Figure 206 represents a species of this genus upon *Quercus agrifolia.* The gall-like swellings on the stem are the adult females; the smaller scales on the leaves are the immature males.

Orthezia (Or-the'zi-a).—The members of this genus occur not uncommonly on various weeds. They are remarkable for the calcareous secretion with which the body is clothed. This is in the form of long plates. Figure 207 represents a nymph; in the adult female the secretion becomes more elongated posteriorly, and forms a sac containing the eggs mixed with a fine down. Later, when the young are born, they remain in the sac till they have themselves secreted a sufficient amount of the lamellar matter to cover them.

FIG. 207.—*Orthezia.* enlarged. (From the Author's Report for 1880.)

Pulvinaria (Pul-vi-na'ria).—This genus includes species in which the body of the female resembles Lecanium, described below, but which excrete a large cottony egg-sac. This egg-sac is not ribbed, but is of the form shown in

Figure 208. The species figured here is sometimes very injurious to maple-trees; it also infests grape-vines and other plants.

FIG. 208.—*Pulvinaria innumerabilis.* Female on grape, natural size (From the Author's Report for 1880.)

Lecanium (Le-ca'ni-um).—The species of the genus Lecanium abound everywhere; they occur on all kinds of

FIG. 209.—*Lecanium oleæ;* 1*a*, insect enlarged. (From the Author's Report for 1880.)

plants, both in conservatories and in the open air. Some of them are known to gardeners as "soft-scales." But the

scientific name is coming into general use; it is a common thing now to hear fruit-growers speak of the Lecaniums, especially in California. The Lecaniums are naked scale insects, the scale being the body of the insect. These insects are flattish or more or less hemispherical, the different species differing in form, and are usually dark brown in

FIG. 210.—*Lecanium hesperidum.* (From the Author's Report for 1880.)

color. The eggs, or the young in the viviparous species, are deposited beneath the scale-like body of the female. Figure 209 represents *Lecanium oleæ* (o'le-æ), which is very common in California, where it is known as the black scale; Figure 210, the soft scale, *Lecanium hesperidum* (hes-per'i-dum), which is common on various plants in all parts of

this country; and Figure 211, the hemispherical scale, *Lecanium hemisphæricum* (hem-i-sphær'i-cum), which occurs in conservatories everywhere, and in the open air in California.

The Armored-scales Sub-family *Diaspinæ* (Di-as-pi'næ).—The great majority of the common scale insects of this

FIG. 211.—*Lecanium hemisphæricum*: 3*a*, insect enlarged. (From the Author's Report for 1880.)

country differ from the forms described above in that the body of the insect, except for a very short period after birth, is covered with a scale composed in part of an excretion of the insect and partly of molted skins. Thus in the Lecaniums the scale-like object is the body of the insect; but in the case of the Oyster-shell Bark-louse, the Pernicious

Scale, and of many other forms, the scale-like object commonly seen is not the insect, but an armor beneath which it lives.

The young insects of this sub-family resemble in general appearance those of other scale insects. Their active stage, however, is much shorter. After crawling about over the

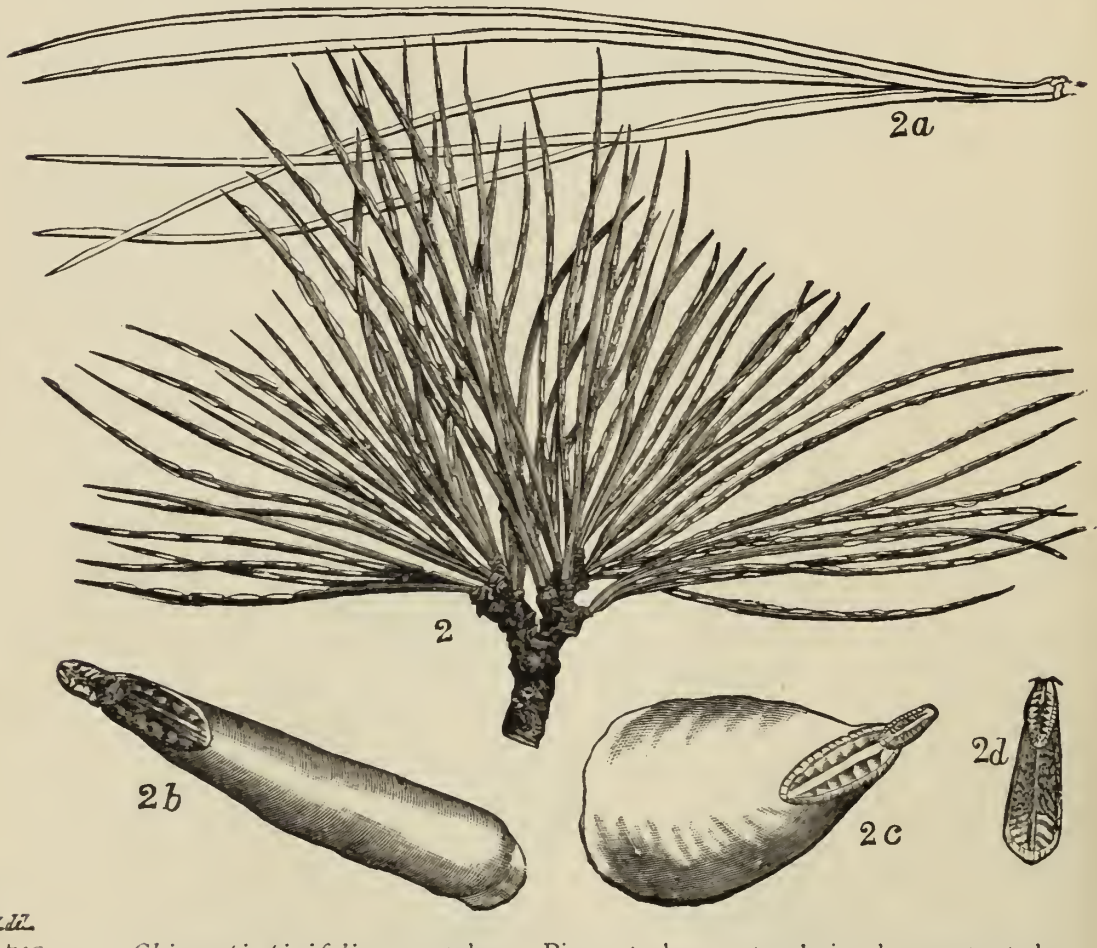

FIG. 212.—*Chionaspis pinifoliæ*: 2, scales on Pinus strobus, natural size, leaves stunted; 2*a*, leaves of P. strobus not stunted by scale insects; 2*b*, scale of female, usual form, enlarged; 2*c*, scale of female, wide form, enlarged; 2*d*, scale of male enlarged.

twigs of a tree for a few days, the young scale insect settles upon a suitable place and immediately begins to excrete a cottony substance which soon becomes compacted into a thin pellicle covering the body. As the insect grows and needs to shed its skin, this cast skin is joined to the excretion and forms a part of the scale. This is the bright-colored, nipple-like prominence, seen in the centre of the Pernicious

Scale and of the Red Scale of the Orange ; and it may be seen at the smaller end of the scale of the Oyster-shell Bark-louse. The position of this cast skin in the scale differs in different genera, and forms a good character for classification.

Closely allied species differ but little in the form of the scale. To distinguish these it is necessary to study the

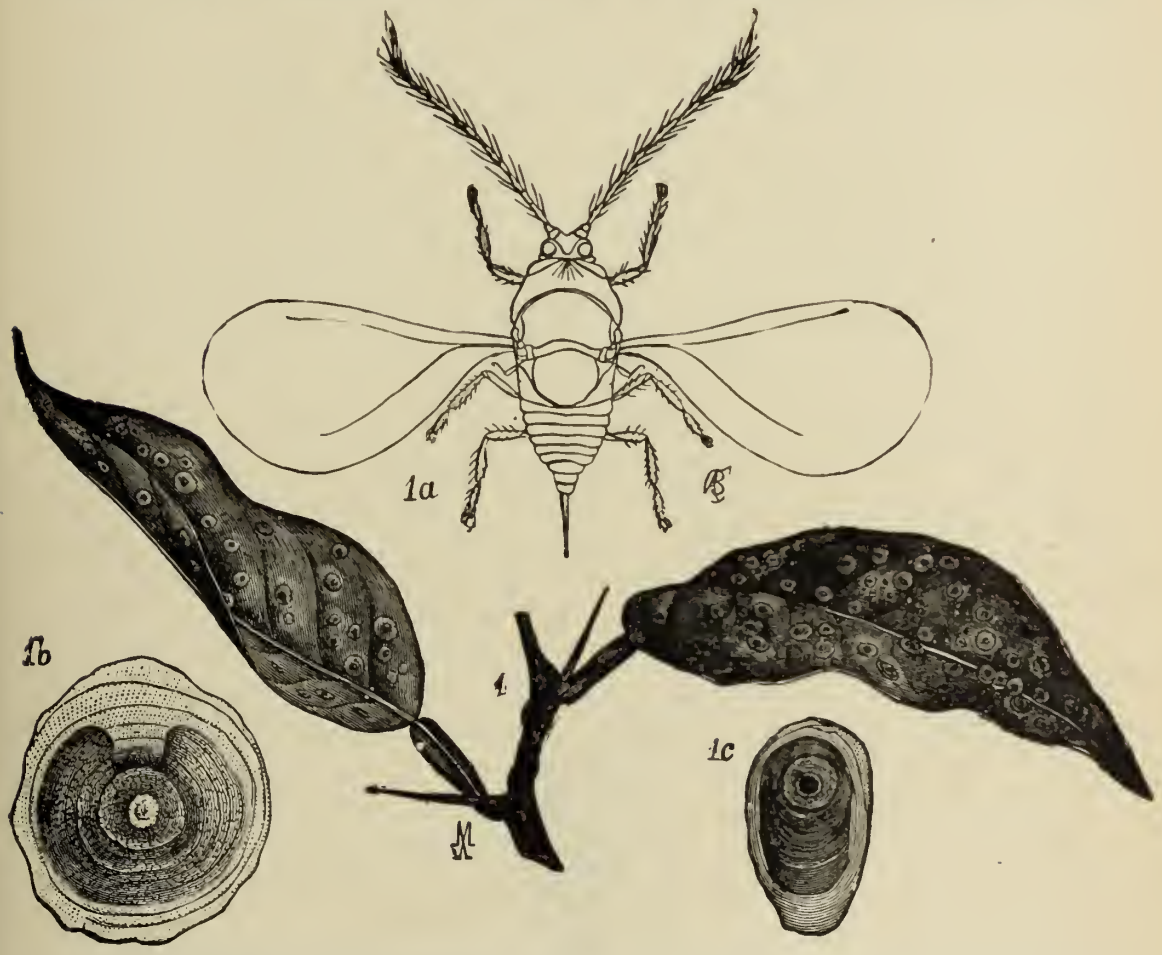

FIG. 213.—*Aspidiotus aurantii ;* scales on leaves of orange, natural size ; 1*a*, adult male, much enlarged; 1*b*, scale of female enlarged; 1*c*, scale of male, enlarged.

insects themselves, which are found beneath the scales The distinctions between closely allied species are such that it requires very close observation and much skill in this particular line to make the determinations, a careful preparation of the specimens and an excellent microscope being necessary requisites.

The different species of scale-insects vary as regards their food habits. We find that certain species infest particular

plants and will feed upon no others; thus, the Red-scale of the Orange does not trouble deciduous fruits. On the other hand, other species have a wide range of food plants. This is the case of the Greedy-scale, which infests a great variety of both cultivated and wild plants.

Figure 202, page 165, represents the Scurfy Bark-louse, *Chionaspis furfurus* (Chi-o-nas'pis fur'fur-us), a species very widely distributed on apple, pear, and cherry; Figure 212, the Pine-leaf Scale, *Chionaspis pinifoliæ* (pin-i-fo'li-æ), which occurs on various species of pine and spruce in all parts of the United States where these trees grow; and Figure 213 represents the red scale of California, *Aspidiotus aurantii* (As-pid-i-o'tus au-ran'ti-i), which is very destructive to oranges and lemons.

FIG. 214.—*Nepa apiculata.* See p. 131.

CHAPTER XV.

Order NEUROPTERA (Neu-rop'te-ra).

The Dobson, Aphis-lions, Ant-lions, and others.

The members of this order have four wings; these are membranous and furnished with numerous veins, and usually with many cross veins. The head is not prolonged into a beak. The mouth-parts are formed for biting. The metamorphosis is complete.

The name of this order is from two Greek words: *neuron*, a nerve; and *pteron*, a wing. It refers to the numerous nerves, or veins as they are more commonly called, with which the wings are furnished.

When the name Neuroptera was first used it was applied to a much larger group of insects than now, a group which has since been divided into many orders. So that now, while the name expresses a character which is true of the order, it is also true of many others.*

The order Neuroptera as now restricted is represented in the United States by seven families. These can be separated by the following table:—

TABLE FOR DETERMINING THE FAMILIES OF NEUROPTERA.

A. Prothorax as long as or longer than the mesothorax and the metathorax combined.

B. Fore legs greatly enlarged and fitted for grasping. p. 179.
MANTISPIDÆ.

* The Neuroptera of the older Entomologists included the following orders: Thysanura, Ephemerida, Odonata, Plecoptera, Isoptera, Corrodentia, Mallophaga, Neuroptera, Mecoptera, and Trichoptera.

BB. Fore legs not enlarged, and not fitted for grasping. p. 178. RAPHIDIIDÆ.

AA. Prothorax not as long as the mesothorax and the metathorax combined.

B. Hind wings broad at the base, and with that part nearest the abdomen (the anal area) folded like a fan when not in use. p. 176. SIALIDÆ.

BB. Hind wings narrow at base, and not folded like a fan when closed.

C. Wings with very few veins, and covered with whitish powder. (As this family includes only very rare insects it is not discussed in this book.) CONIOPTERYGIDÆ.

CC. Wings with numerous veins, and not covered with powder.

D. Antennæ gradually enlarged towards the end, or filiform with a terminal knob. p. 182. MYRMELEONIDÆ.

DD. Antennæ without terminal enlargement.

E. Some of the transverse veins between the costa and subcosta forked (in all common forms), wings brownish or smoky. p. 181. HEMEROBIIDÆ.

EE. Transverse veins between the costa and subcosta simple, wings greenish. p. 180. CHRYSOPIDÆ.

Family SIALIDÆ (Si-al'i-dæ).

The Dobson and others.

The members of this family differ greatly in size and appearance ; but they agree in having the hind wings wide at the base, and in having that part of these wings nearest the abdomen (the anal area) more or less folded in plaits when the wings are closed.

The species that is most likely to attract attention is the Horned Corydalis, *Corydalis cornuta* (Co-ryd'a-lis cor-nu'ta). This is a magnificent insect, which has a wing expanse of from four to nearly five and a half inches. Figure 215 represents the male, which has remarkably long mandibles. The female resembles the male, except that the mandibles are comparatively short.

This species is common throughout the United States. The larvæ are called Dobsons by anglers and are used by them for bait, especially for bass. Figure 216 represents a full-grown Dobson, natural size. These larvæ live under stones in the beds of streams. They are most abundant where the water flows swiftest. They are carnivorous, feeding upon the nymphs of Stone-flies, May-flies, and other insects.

FIG. 215.—*Corydalis cornuta.*

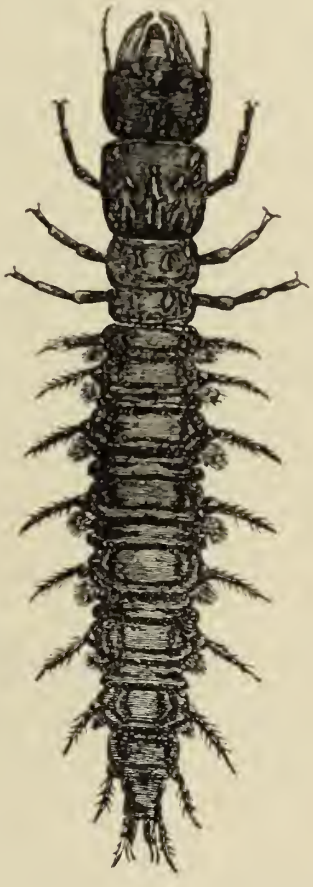

FIG. 216.—*Corydalis cornuta*, larva.

When about two years and eleven months old, the larva leaves the water, and makes a cell under a stone or some other object on or near the bank of the stream. This occurs during the early part of the summer; here the larva changes to a pupa. In about a month after the larva leaves the water the adult insect appears. The eggs are then soon laid;

these are attached to stones or other objects overhanging the water. They are laid in blotch-like masses, which are chalky-white in color, and measure from half an inch to nearly an inch in diameter. A single mass contains from two thousand to three thousand eggs. When the larvæ hatch they at once find their way into the water, where they remain until full grown.

There are other common species of the family which closely resemble *Corydalis* but are smaller, the larger ones measuring less than two and a half inches in length, and having a wing expanse of not more than four inches. These insects also differ from Corydalis in having three ocelli and in lacking the sharp tooth-like angles on the sides of the back part of the head. See Figure 215 of the adult *Corydalis*. These species belong to the genus *Chauliodes* (Chau-li'o-des).

Chauliodes pecticornis (pec-ti-cor'nis) is a common species with grayish wings and feather-like antennæ. *Chauliodes serricornis* (ser-ri-cor'nis) is also common ; this is a brownish-black species with the wings spotted with white, and with serrate antennæ.

Family RAPHIDIIDÆ (Raph-i-di'i-dæ.)

The Raphidians (*Ra-phid'i-ans*).

The members of this family are found in this country only in the far West. They are strange-appearing insects, the prothorax being greatly elongated, like the neck of a camel (Fig. 217). The female bears a long, slender, sickle-shaped ovipositor at the end of the abdomen. The fore legs resemble the other pairs of legs, and are borne at the hinder end of the prothorax.

FIG. 217.—*Raphidia*, female.

The larvæ are found under bark and are carnivorous. We have found them common under the loose bark of the Eucalyptus. They also occur in orchards, and doubtless do good by destroying the larvæ and pupæ of the Codlin-moth.

Living specimens of these insects have been sent to Australia by our government in the hope of introducing the species there, and thus doing something towards repaying the debt that we owe that country for the Australian Lady-bug, which has rendered us great service in the destruction of the Cottony-cushion Scale in California.

The family is represented by two genera, *Raphidia* (Raphid'i-a) and *Inocellia* (In-o-cel'li-a). In the former there are three simple eyes on the top of the head between the compound eyes; in the latter these ocelli are wanting.

Family MANTISPIDÆ (Man-tis'pi-dæ).

The Mantis-like Neuroptera.

The members of this family are even stranger in appearance than the Raphidians. Here, as in that family, the prothorax is greatly elongated; but the members of this family can be easily recognized by their remarkable fore legs, which are greatly enlarged and resemble those of the Praying Mantes in form (Fig. 218). These legs are fitted for seizing prey; and, in order that they may reach farther forward, they are joined to the front end of the long prothorax. In the adult state these insects are predaceous; while the larvæ, so far as is known, are parasitic in the egg-sacs of spiders.

FIG. 218.—*Mantispa*. In the specimen figured the fore legs were twisted somewhat in order to show the form of the parts.

Five species of the family are known from the United States; four of these belong to the genus *Mantispa* (Mantis'pa) and one to *Symphasis* (Sym'pha-sis).

Family CHRYSOPIDÆ (Chry-sop'i-dæ).

The Lace-winged-flies or Aphis-lions.

If one will search the foliage of herbs, shrubs, or trees, there may be found, running rapidly around on the leaves, sturdy, spindle-formed, little insects that have great sickle-shaped jaws (Fig. 219). These larvæ are always hungry, and will kill and eat any insects that they can overpower;

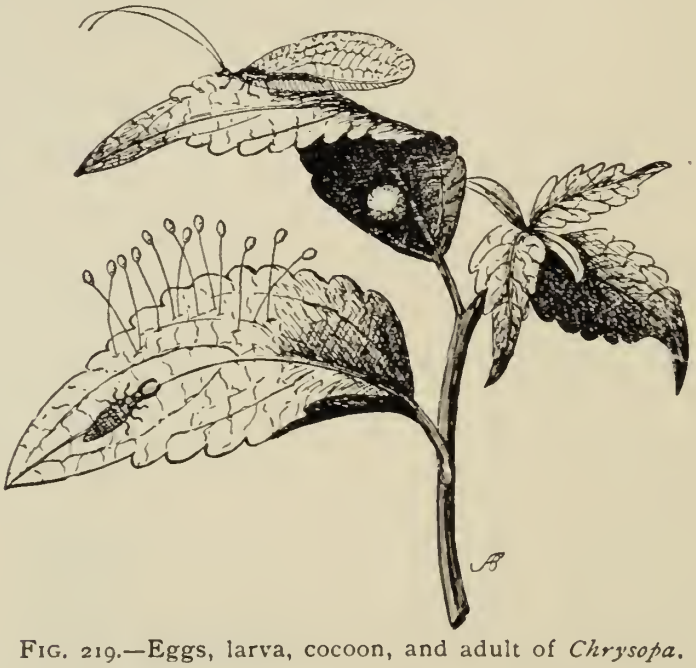

FIG. 219.—Eggs, larva, cocoon, and adult of *Chrysopa*.

but as they are especially destructive to plant-lice, they are called Aphis-lions.

When an Aphis-lion is full grown it rolls itself up into a tiny ball and weaves around itself a glistening, white cocoon, which looks like a large seed-pearl. It may be supposed that while the Aphis-lion is secluded in this pearly cell it repents its greedy, murderous ways, and changes in spirit; at least the body changes greatly, for, after a time, a circular lid is made in the cocoon, and out of this emerges a beautiful, dainty creature, with delicate-veined, green wings, a pale green body, slender, brown antennæ, and a pair of large eyes that shine like melted gold. It is

sometimes called Golden-eyes, and sometimes, a Lace-winged-fly, from its appearance. The Lace-wing is a prudent mother; she knows that if she lays her eggs together on a leaf the first Aphis-lion that hatches will eat for his first meal all his unhatched brothers and sisters. She guards against this fratricide by laying each egg on the top of a stiff stalk of hard silk about half an inch high. Groups of these eggs are very pretty, looking like a tiny forest of white stems bearing on their summits round glistening fruit. When the first of the brood hatches, he scrambles down as best he can from his egg perch to the surface of the leaf, and runs off, quite unconscious that the rest of his family are reposing in peace high above his head.

The mouth-parts of these larvæ are very unusual in form. The mandibles are very long; on the lower side of each of them there is a furrow the entire length; into this furrow the long and slender maxilla fits. In this way the mandible and the maxilla of each side form a tube, through which the blood of the prey of the insect can be drawn. This explains why an Aphis-lion holds its prey on the tips of its long jaws, at arm's length, as it were, while sucking its blood.

Nearly all of the members of this family belong to the genus *Chrysopa* (Chry-so'pa).

Family HEMEROBIIDÆ (Hem-e-ro-bi'i-dæ).

The Hemerobians (*Hem-e-ro'bi-ans*).

The common members of this family are rather dark-colored insects, with the wings mottled with dark brown or smoky specks, and with some of the veins between the costa and subcosta forked.

The most conspicuous member of the family is *Polystœchotes punctatus* (Pol-ys-tœch'o-tes punc-ta'tus), which is represented natural size by Figure 220. The larva is unknown.

The larger number of the species of this family belong to the genus *Hemerobius* (Hem-e-ro'bi-us). These are small-ish insects, the largest of which expands hardly an inch. They occur in forests, and especially on cone-bearing trees. The larvæ bear a strong resemblance to the Aphis-lions, and like them feed upon Aphids and other small insects. After sucking the blood from their victims, they make cloaks for themselves of the empty skins.

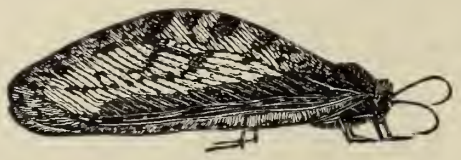

FIG. 220.—*Polystœchotes punctatus.*

Family MYRMELEONIDÆ (Myr-me-le-on'i-dæ).

The Ant-lions and others.

The Ant-lions, *Myrmeleon* (Myr-me'le-on). — In sandy places beneath overhanging cliffs, beneath buildings, and along sandy banks where the sun shines warmest, there may be found, in all parts of our land, little, funnel-shaped pits one or two inches across (Fig. 221). The sides are smooth and as steep as the sand will lie; and at the bottom may be seen two small curved objects. All is still and motionless until some ant, hurrying along with mind intent upon business, carelessly runs over the edge of one of these pitfalls. Then the ant commences to slide down, while some force below throws out the sand from under its struggling feet, until it slides into the bottom, where literally jaws of death are awaiting it. For the curved objects are a pair of jaws, attached to a strong head, and closely connected with a greedy stomach. If we dig out the owner of the jaws we find it a spry, humpbacked creature, which moves backward more easily than forward. It is worth while to collect some

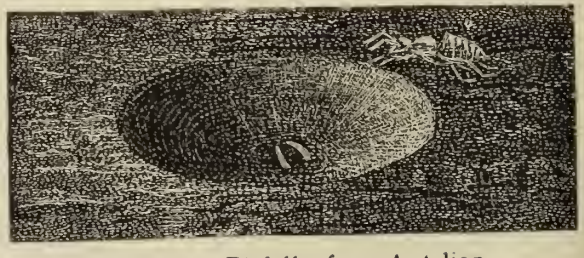

FIG. 221.—Pitfall of an Ant-lion.

of these larvæ, and place them in a basin of sand, and watch them build their pits. They do this by using the head for a shovel. Sometimes when an ant seems likely to escape, the Ant-lion will throw up a torrent of sand so that it will descend on the victim, knocking it back into the pit.

When ready to change to a pupa the Ant-lion makes for itself a little, round cocoon of sand fastened together and lined with silk. The adult Ant-lion is a graceful insect with long, narrow, delicate wings, and a slender body (Fig. 222).

FIG. 222.—Larva, cocoon with pupa-skin projecting, and adult of an Ant-lion.

Certain members of this family differ from the ant-lions in having long, filiform antennæ, which are suddenly enlarged at the end. These belong to the genus *Ascalaphus* (As-cal′a-phus).

CHAPTER XVI.

Order MECOPTERA (Me-cop'te-ra).

The Scorpion-flies and others.

The members of this order have four wings; these are membranous, and furnished with numerous veins. The head is prolonged into a beak, at the end of which biting mouth parts are situated. The metamorphosis is complete.

This is a small order composed of very remarkable insects. The most striking character common to all is the shape of the head, which is prolonged into a beak (Fig. 223). The name *Mecoptera* is from two Greek words; *mecos*, length; and *pteron*, a wing. This order includes only a single family, the *Panorpidæ*.

FIG. 223.—Head and tail of *Panorpa*.

Family PANORPIDÆ (Pa-nor'pi-dæ).

The Scorpion-flies and others.

We have found representatives of this family quite abundant on rank herbage growing on the banks of a shaded stream; we have also found them in damp woods where there was a luxuriant undergrowth of herbaceous plants. These insects take flight readily when disturbed; they are carnivorous both in the adult and in the larval state. The larvæ larvæ so far as known are remarkable on account of their great resemblance to caterpillars. Not only is the form of the body like that of a caterpillar, but the abdomen is furnished with fleshy pro-legs. There are, however, eight pairs of these; while caterpillars, as a rule, have only five.

The most common members of this family are the Scorpion-flies, *Panorpa* (Pa-nor'pa). These are called Scorpion-flies on account of the peculiar form of the caudal part of the abdomen of the male (Fig 223). This at first sight suggests the corresponding part of a scorpion; but in reality the two are very different. The last segment, instead of ending in a sting like that of a scorpion, is greatly enlarged and bears a pair of clasping organs. The wings are narrow but are well developed, being longer than the body. In our more common species they are yellowish, spotted with brownish black (Fig. 224).

FIG. 224. — *Panorpa*, adult.

Very closely allied to the Scorpion-flies are the insects of the genus *Bittacus* (Bit'ta-cus). These insects have long narrow wings, long legs, and a slender abdomen. They resemble crane-flies very closely when on the wing. In this genus the caudal appendages of the male are not enlarged as in *Panorpa*.

The species of the genus *Boreus* (Bo're-us) are remarkable for occurring on snow, in the winter, in our Northern States.

CHAPTER XVII.

Order TRICHOPTERA (Tri-chop'te-ra).

The Caddice-flies or Caddice-worms.

The members of this order have four wings; these are membranous, furnished with numerous longitudinal veins but with only few cross veins, and are more or less densely clothed with hairs. The mouth-parts are rudimentary. The metamorphosis is complete.

The Caddice-flies are moth-like insects which are common in the vicinity of streams, ponds, and lakes; and they are also frequently attracted to lights at night.

The body-wall of these insects is soft, being membranous or at the most parchment-like, and is thickly clothed with hairs. There are usually four ample wings. These are membranous; but the fore pair are more leathery than the hind pair. When not in use they are folded against the sides of the abdomen, in an almost vertical position, and give the insect a narrow and elongated appearance (Fig. 225). The wings are more or less densely clothed with hairs; and in some cases the hairs are scale-like in form. The hind wings are usually broader than the fore wings, and are often longitudinally folded in repose. All have numerous longitudinal veins, but the cross veins are few.

FIG. 225.—Caddice-fly.

The name of the order is from two Greek words: *thrix*, a hair; and *pteron*, a wing.

The order includes only a single family, the *Phryganeidæ*.

Family PHRYGANEIDÆ (Phryg-a-ne'i-dæ).

The Caddice-flies or Caddice-worms.

The young naturalist loves to lie face downward on the bank of a brook, and, with shaded eyes, watch the busy life that goes on there. Among the astonishing things he sees are little bundles of sticks or masses of stones moving about the bottom of a quiet pool as if they were alive; and yet if he takes them out they seem dead enough. But when he pulls them apart he finds that each is a tube lined with silk within which a whitish larva lives. This larva, when it wishes to move, puts out the front part of its body, so that it can creep with its legs over the bottom of the stream, or climb up and down water-plants, dragging its house along after it. When molested it draws back into its tube, and is safe. Larvæ of this sort are called Caddice-worms; and the adult insects are known as Caddice-flies.

There are very many species of Caddice-worms; and each species makes a particular kind of tube. Some Caddice-worms are carpenters, building their houses of straws or sticks. These are usually placed lengthwise the body (Fig. 226); but certain species that make their houses chiefly of straws fasten the straws crosswise like the logs of a log-house (Fig. 227). These log-house builders often have the curious habit of decorating their houses by fastening snail-shells to the outside. And strangely enough they do not always take empty shells for this purpose; we have found shells containing living snails securely fastened to the outside of the house of a Caddice-worm. In this case the snail was afforded comparatively rapid transportation whether it desired it or not. Fortunately the species that

FIG. 226.

FIG. 227.

make this style of house live in still water, and may, therefore, be easily kept alive in aquaria.

There are caddice-worm houses closely resembling in plan those just described but differing in appearance, being made of bits of moss. Sometimes the houses are built of leaves; these may be fastened so as to form a flat case; or are arranged in three planes, so as to form a tube, a cross-section of which is a triangle.

Other Caddice-worms are masons, building their houses of grains of sand or of small stones. Sometimes these houses are tubes very regular in outline, being composed only of grains of sand fastened together with silk; but certain species of Mason Caddice-worms fasten larger stones on each side of this tube of sand (Fig. 228). Some of the species that

FIG. 228.

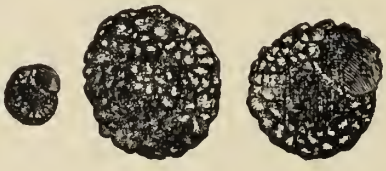

FIG. 229.

build tubes of sand make spiral houses which very closely resemble in form snail-shells (Fig. 229).

Whether stones or wood are used to build these houses the material is always fastened together by silk, which the larvæ spin from the mouth in the same manner as do caterpillars. In some species the case is composed entirely of silk. Figure 230 represents the form of such a case, which is common in some of our lakes.

FIG. 230.

Among the simplest of the various forms of houses built by Caddice-worms are those made by certain species that live under stones in rapid streams. These consist merely of a few pebbles fastened to the lower surface of a larger stone by threads of silk. In the space between these pebbles the worm makes a more or less perfect tube of silk, within which

it lives. Very little respect for the architectural skill of these builders is commanded by their rude dwellings. But if one looks a little farther, something will be found that is sure to excite admiration. The dweller within this rude retreat is a fisherman ; and stretched between two stones near by can be seen his net. This is made of silk. It is usually funnel-shaped, opening up-stream ; and in the centre of it there is a portion composed of threads of silk extending in two directions at right angles to each other, so as to form meshes of surprising regularity. It is as if a spider had stretched a small web in the water where the current is the swiftest. These nets occur in rapids between stones, but in many places they are to be found in greater numbers along the brinks of falls. Here they are built upon the surface of the rock, in the form of semi-elliptical cups, which are kept distended by the current. Much of the coating of dirt with which these rocks are clothed in summer is due to its being caught in these nets. We have not yet observed the owners of the nets taking their prey from them ; but we cannot doubt that they are made to trap small insects or other animals that are being carried down-stream ; for the larvæ of the sub-family to which these net-builders belong, the *Hydropsychinæ*, are known to be carnivorous. It should be noted here, however, that the greater number of Caddice-worms are herbivorous.

When a Caddice-worm gets ready to change to a pupa it retires into its house and builds a door to keep intruders out ; but the door always has an opening to allow the water to flow in so that the pupa can breathe. Sometimes a simple grating of silk is made over the entrance.

On one occasion the writer had the good fortune to observe a Caddice-fly leave the water and take its first flight. The specimen was one of the net-building species, *Hydropsyche* (Hy-drop-sy'che), which I was breeding in an aquarium in my laboratory. It swam to the surface of the water repeatedly, using its long middle legs. When swimming,

these legs were extended at right angles to the body like a pair of oars. The insect was unable to crawl up the vertical side of the aquarium, and after clinging to it for a short time it would lose its hold and sink back to the bottom. After watching it for a time I lifted it from the water by means of a stick. At this time its wings were in the form of pads, which were but little, if any, longer than the wing-pads of the pupa, as shown by the cast pupa-skin found floating on the water. The instant the creature was free from the water its wings expanded to their full size, and immediately it flew away several feet. In my efforts to catch the insect I found that it had perfect use of its wings, although they were so recently expanded. The time required for the insect to expands its wings and take its first flight was scarcely more than one second; it was certainly less than two. As these insects normally emerge from rapidly-flowing streams which dash over rocks, it is evident that if much time were required for the wings to become fit for use, as is the case with most other insects, the wave succeeding that which swept one from the water would sweep it back again and destroy it.

CHAPTER XVIII.

Order LEPIDOPTERA (Lep-i-dop'te-ra).

The Moths or Millers, the Skippers, and the Butterflies.

The members of this order have four wings; these are membranous, and covered with overlapping scales. The mouth-parts are formed for sucking. The metamorphosis is complete.

The name of this order is from two Greek words: *lepis*, a scale; and *pteron*, a wing. It refers to the fact that the wings of these insects are covered with scales. Every lad that lives in the country knows that the wings of moths and butterflies are covered with dust, which comes off upon one's fingers when these insects are handled. This dust when examined with a microscope is found to be composed of very minute scales of regular form; and when a wing is looked at in the same way, the scales are seen arranged with more or less regularity upon it. The body, the legs, and other appendages are also covered with scales.

The scales of Lepidoptera are modified hairs. That is, they are hairs which, instead of growing long and slender as hairs usually do, remain short, but grow very wide as compared with their length. Every gradation in form can be found from the ordinary hair-like form, which occurs most abundantly upon the body, to the short and broad scale, which is best seen upon the wings.

There is a great difference among the insects of this order regarding the regularity of the arrangement of the scales

upon the wings. With some of the lower moths the scales are scattered irregularly over the wings. But if the wing of one of the higher butterflies be examined with a microscope, the scales will be found arranged in regular, overlapping rows; the arrangement being as regular as that of the scales on a fish or of the shingles on a roof (Fig. 231). In the upper part of the figure the membrane is represented with the scales removed.

FIG. 231.—Part of wing of butterfly, greatly magnified.

The use of the scales on the wings is to strengthen them. We thus see that the wings of these insects are furnished with much fewer cross veins than are the wings of similar size in other orders. A secondary use of these scales is that of ornamentation; for the beautiful colors and markings of these insects are due entirely to the scales, and are destroyed when the scales are removed. Upon the body, legs, and

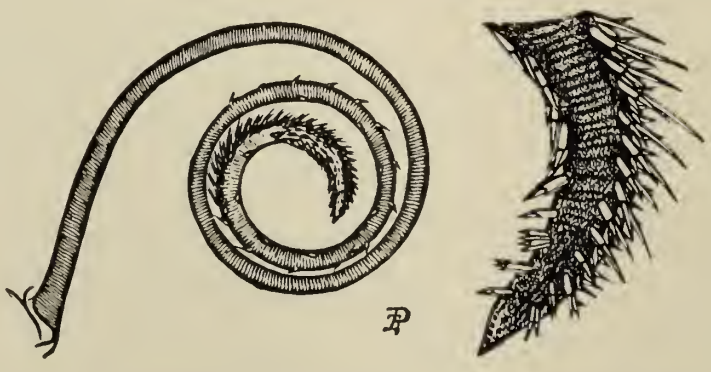

FIG. 232.—Maxillæ of cotton-moth, and tip of same enlarged

other appendages, the scales and hairs doubtless serve to protect the insect, being a sort of armor.

The mouth-parts of moths and butterflies are especially adapted for sucking nectar from flowers. If the head of a butterfly be examined, there will be found a long sucking

tube, which when not in use is coiled on the lower side of the head between two forward-projecting appendages. This long sucking tube is composed of the two maxillæ, greatly elongated, and fastened together side by side. In Figure 232 there is represented a side view of the maxillæ of a moth; and in Figure 233 a cross-section of these organs. Each

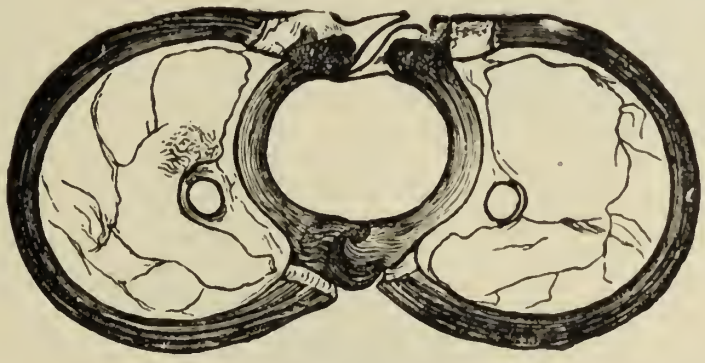

FIG. 233.—Cross-section of maxillæ.

maxilla is furnished with a groove, and the two maxillæ are so fastened together that the two grooves form a tube through which the liquid food is sucked. As a rule the maxillæ of insects of this order are merely fitted for extracting the nectar from flowers, but sometimes the tips of the maxillæ are armed with spines, as shown in Figure 232. This enables the insect to lacerate the tissue of ripe fruits and thus set free the juice, which is then sucked up. Many moths do not eat in the adult state; with these the maxillæ are wanting. The two forward-projecting organs between which the maxillæ are coiled when present are the labial palpi. In some moths the maxillary palpi are also developed.

The larvæ of Lepidoptera are known as caterpillars. They vary greatly in form and appearance; but are usually cylindrical, and provided with from eight to sixteen legs,—six thoracic legs, and from two to ten abdominal legs. The thoracic legs, which are finally developed into the legs of the adult, have a hard external skeleton; and are jointed, tapering, and armed at the end with a little claw. The abdominal legs, which are shed with the last larval skin, are thick,

fleshy, without joints, elastic or contractile, and are generally surrounded at the extremity by numerous, minute hooks (Fig. 234); they are termed pro-legs.

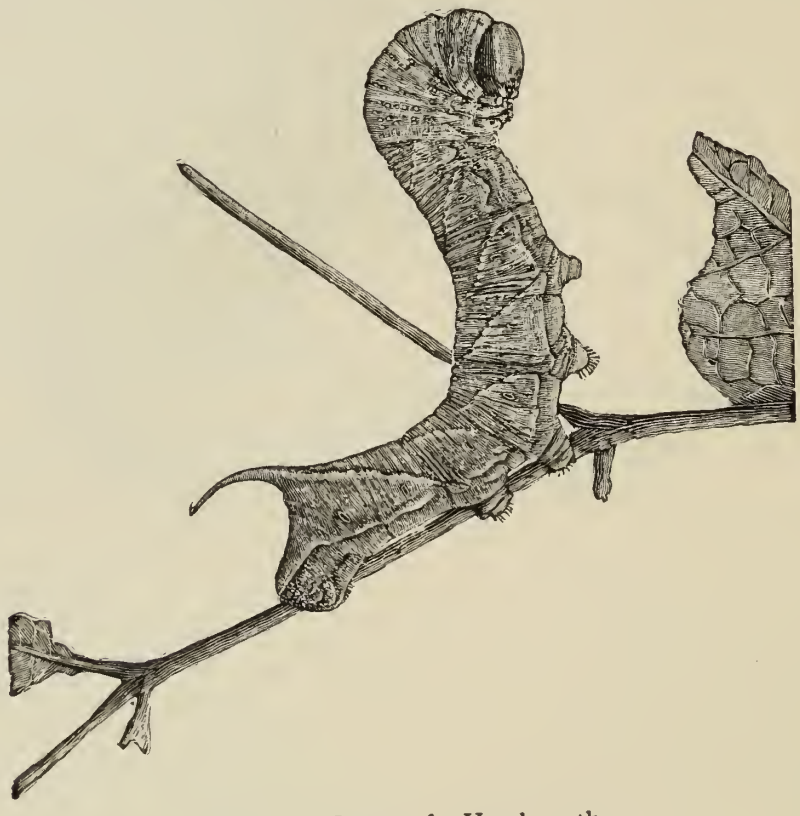

FIG. 234.—Larva of a Hawk-moth.

Most caterpillars, except the larvæ of butterflies, spin cocoons (Fig. 235). In some instances, as in case of the

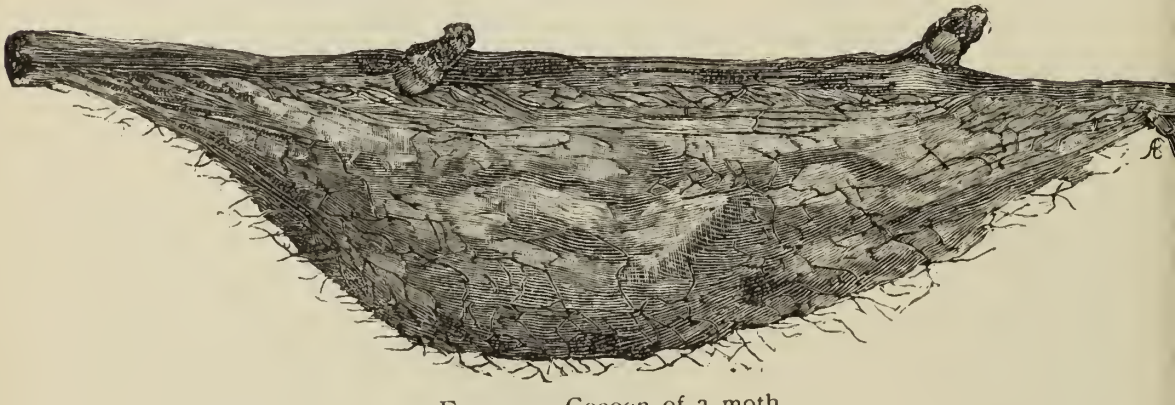

FIG. 235.—Cocoon of a moth.

silkworms, a great amount of silk is used in the construction of the cocoon; in others the cocoon is composed principally

of the hairs of the larva, which are fastened together with a fine web of silk.

In the pupæ of Lepidoptera the developing wings and legs are folded upon the sides and breast; the whole being enclosed in a hard skin (Fig. 236).

Fig. 236.—Pupa of a moth.

The members of this order as a rule feed upon plants, and are not aquatic; some, as the Clothes-moth and the species that destroy Scale-bugs, feed on animal matter, and a very few feed upon plants below the surface of the water.

More than six thousand species of Lepidoptera are known to occur in America, north of Mexico. These represent more than sixty families.

In order to give a synopsis of the Lepidoptera it is necessary to enter into rather difficult technical details. Hence this is done in that portion of this chapter designed for advanced students and printed in fine type. The principal divisions of the Lepidoptera that are appropriately discussed here are three: the moths, the skippers, and the butterflies:—

The Moths.—These are the insects commonly called millers. Most of the species fly by night and are frequently attracted to lights. When at rest the wings are either wrapped around the body, or are spread horizontally, or are folded roof-like on the abdomen; they are not held in a vertical position above the body. The antennæ of moths are of various forms; they are usually thread-like or feather-like; only in rare cases are they enlarged towards the tip. The moths include all but the last six families of Lepidoptera.

The Skippers.—The skippers are so called on account of their peculiar mode of flight. They fly in the daytime and dart suddenly from place to place. When at rest they

usually hold the wings erect in a vertical position like butterflies; often the fore wings are thus held while the hind wings are extended horizontally. The antennæ are thread-like, and enlarged towards the tip; but in most cases the extreme tip is pointed and recurved, forming a hook. The abdomen is usually stout, resembling that of a moth rather than that of a butterfly. This division includes two families.

The Butterflies.—The butterflies fly by day; and when at rest they fold the wings together above the back in a vertical position. The antennæ are thread-like with a club at the tip, which is never recurved so as to form a hook. The abdomen is slender. This division includes the last four families described in this chapter.

Classification of the Lepidoptera.

(*For Advanced Students.*)

The study of the classification of the Lepidoptera is beset by a peculiar difficulty. As these insects are clothed with scales comparatively little of their structure can be examined without injury to the specimens studied. Fortunately, however, it has been found that the various modifications of the framework of the wings afford excellent clues to the relationships of the different groups; and these modifications can be determined in most cases without serious injury to the specimens. The structure of the antennæ also can be easily studied, and in many cases affords much help in determining the zoological position of an insect.

The first step to be taken in the study of the classification of these insects is to become thoroughly familiar with the nomenclature of the wing veins; this is given on pages 64 to 66. It is a good plan to take several of the larger moths and butterflies and make drawings showing the courses of the veins of the wings in each, carefully indicating the names or numbers of the veins on the drawings. The making of such drawings will be of much use in fixing the arrangement of the veins in the student's mind. It should be remembered that veins IV and VI are not developed in this order.

As the scales on the lower surface of the wings are more closely applied to the wings than are those on the upper surface, the veins can be best seen when the wings are examined from below. The

veins can be rendered more distinct for a few seconds by putting a drop of chloroform on the part of the wing to be examined; this can be easily done by means of a camel's-hair brush.

Sometimes it is necessary to remove the scales from a small part of the wing in order to determine the nature of some characteristic; this can be easily done with an artist's sable brush. A very small brush is best for this purpose; and care should be taken not to break the wing.

The above methods are all that are needed in the majority of cases where the mere determination of an insect is the object. But when a very careful study of the venation of a wing is to be made, it should be bleached and mounted on a card or on a glass slip in order that it may be studied with a compound microscope. The following is the method of bleaching wings:—

1. Remove the wings carefully so as not to break the frenulum if there be one; it is well to remove the patagium first.

2. Dip the wings in alcohol in order to wet them.

3. Immerse them for an instant in hydrochloric acid (muriatic acid). Use for this purpose dilute acid, one part acid to nine parts water.

4. Put them in Labaraque solution with the upper surface of the wings down, and leave there till the color has been removed from the scales. If a wing bleaches slowly, the process can be hastened by dipping it in the dilute acid and returning it to the Labaraque solution from time to time. This solution can be procured of most druggists. It deteriorates if left exposed in strong sunlight. If it cannot be obtained, use an aqueous solution of chloride of lime.

5. When a wing is bleached put it in alcohol and leave it there till after it floats. This is to wash off the Labaraque solution. The wing can then be mounted on a card. But it is better to mount it as described below.

6. Transfer the wing to a clearing mixture, if it is to be mounted in balsam, and leave it there five or ten minutes. This is to remove any water there may be on it. A good clearing mixture can be made by mixing two parts by weight of carbolic-acid crystals and three parts of rectified oil of turpentine.

7. Put the wing on a glass slip with considerable clearing mixture under it to avoid bubbles; put Canada balsam on top, and cover with thin glass. In the case of small wings, it is best to transfer them from one solution to another, and to the glass slip by means of a camel's-hair brush.

Wings bleached and mounted in this way make an important addition to a collection. The slides should be carefully labelled; and

the insect from which the wings were taken should be kept with the slide. It is our practice to remove always the wings from the right side, and then to mount the slide in the collection at the right of the insect from which the wings were taken. Uniformity in this respect adds greatly to the appearance of the collection.

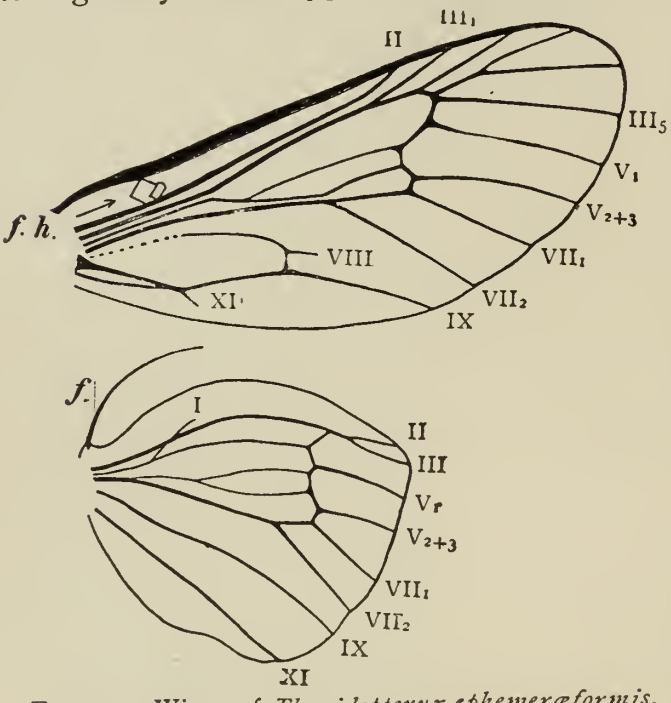

FIG. 237.—Wings of *Thyridopteryx ephemeræformis*.

The student should study his larger specimens first, leaving the smaller ones till he has acquired skill in this work.

There are a few special terms used in describing the wings of the Lepidoptera which should be learned:—

Frenulum.—In most moths there is a strong spine or a bunch of bristles borne by the hind wing at the humeral angle (Fig. 237, *f*); this is the frenulum. Its use is to insure the acting together of the two wings of one side. Except in the Microlepidoptera the frenulum of the male consists of a single strong spine; that of the female of two or more bristles.

Jugum.—In one suborder, including only a few rare moths, there exists, instead of a frenulum, a lobe borne near the base of the inner margin of the fore wing (Fig. 238, *j*); this is the jugum. See sub-order Jugatæ.

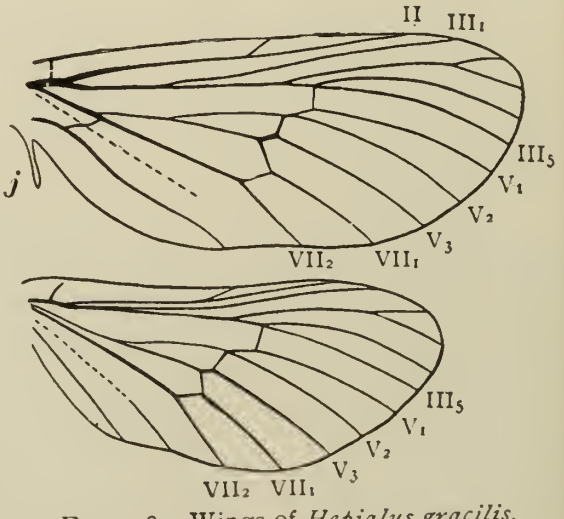

FIG. 238.—Wings of *Hepialus gracilis*.

Discal Cell.—Near the centre of the basal part of the wing there is a large cell lying between veins III and VII (Fig. 239, *d.c.*); this is the discal cell. In the more generalized Lepidoptera this cell is divided into two parts by the base of vein V (Fig. 239, hind wing); in such cases the

cell lying immediately behind vein III is cell III, and that lying immediately behind vein V is cell V.

Accessory Cells.—In many genera the branches of vein III of the fore wings anastomose so as to form one or more cells beyond the apex of the discal cells (Fig. 239, *a.c.*); these are the accessory cells.

Discal Vein. — The cross vein at the outer end of the discal cell is termed the discal vein (Fig. 239, *d.v.*).

Patagia. — At the base of each fore wing there is a scale-like appendage; these are the patagia. The patagia correspond to the tegulæ of the Hymenoptera and the elytra of the Coleoptera.

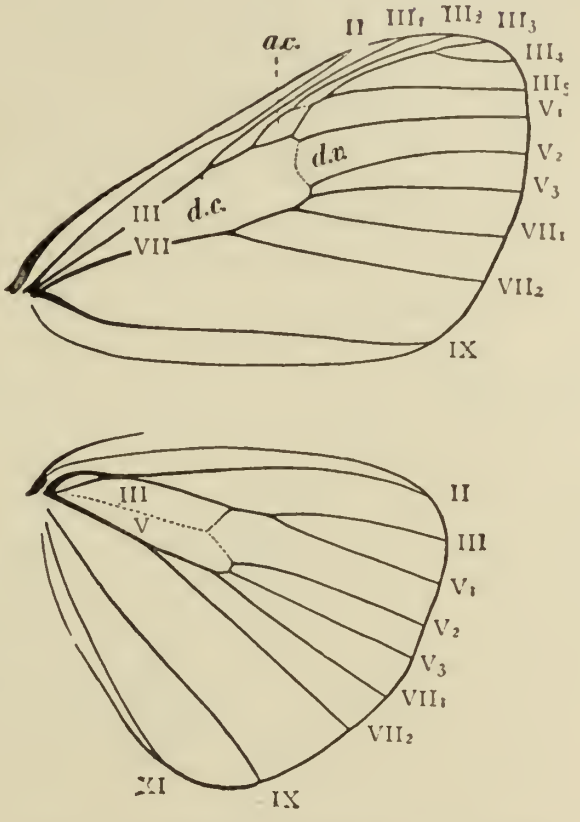

FIG. 239.—Wings of *Notolophus leucostigma.*

In descriptions of Lepidoptera reference is often made to the palpi. These form the double beak-like projection which extends forward from the lower surface of the head. In most Lepidoptera only the labial palpi are well developed; but in some of the more generalized forms the maxillary palpi are also present.

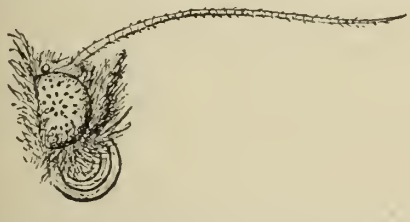

FIG. 240.—Head of moth, showing position of ocellus.

The presence or absence of ocelli is a character which is sometimes of considerable importance. These organs are situated, one on each side, above the compound eye and near its margin (Fig. 240). But it requires some skill to find them when they are present, on account of the long scales clothing the head.

The Phylogeny of the Lepidoptera.—Since the general acceptance of the theory of evolution—that is, the theory that the higher animals and plants have been developed from lower ones—it has become evident that the only sure basis for classification is a knowledge of the

history of the various races of animals and plants, or phylogeny (phy-log'e-ny), as it is termed.

The scope of this book has not permitted an extended treatment of this phase of the subject. There is space for only a few hints regarding the phylogeny of the families of a single order; but these hints will serve as an illustration of a method of study. The Lepidoptera is chosen for this purpose, as the method has been applied to this order more fully than it has to others.

It is a well-known fact that every kind of animal and plant transmits a general likeness with individual differences to its offspring.

According to the Darwinian theory of natural selection these differences or variations may be of any kind and in any direction. And as many more animals are born or plants germinated than can live to reach maturity, owing to the tendency of each kind to increase in a geometrical ratio, each individual is subjected to a severe struggle for existence.

The result of this struggle is that any individual possessing a fortunate variation—that is, one that enables it to get its living and escape its dangers more easily than its fellows—will be more apt on this account to reach maturity and propagate its kind than will less fortunate individuals. Thus there is a thinning-out process which tends to the production of more and more *specialized* forms of animals and plants, i.e., forms adapted to the special conditions under which they exist.

It should be remembered that the difficulties surrounding existence may be met in different ways; and that thus there may have descended from a common ancestor very different forms, each well fitted to meet the struggle for existence. See Chapter I, pp. 1 and 2.

Just what changes have taken place in the structure of the members of any race is a difficult matter to determine, for, although many fossils have been found, the record is still very incomplete. But fortunately something can be learned regarding this by the study of living animals. For not all members of the same family, or order, or class are equally specialized. Some retain more nearly than others the form of their remote ancestors; and by the study of these *generalized* forms, as they are termed, we can gain some idea of the structure of the animals of past ages, and of the ways in which existing animals have been modified.

We will state very briefly some of the conclusions that we have reached regarding the phylogeny of the families of the Lepidoptera. These conclusions are based largely on a study of the wings. It is hoped that other parts will be studied in the same way ere long.

In the flight of insects it is important that the two wings of each side should act together, and we find that this is secured in most orders by uniting them in some way. In the Lepidoptera two distinct methods are employed; in some it is done by means of a *jugum*, in others by means of a *frenulum* or its substitute. As neither the jugum nor the frenulum could be derived from the other, we infer that the primitive Lepidoptera possessed neither of these organs, but had wings that were quite distinct from each other. In the course of time there was developed in some of the descendants of these primitive forms a jugum; while in others there was developed a frenulum. Of course in each case the development was a gradual one, extending through many generations. Thus the frenulum at first was probably merely a bunch of hairs like those elsewhere on the wings; but these became stiffer and stiffer in succeeding generations.

The descendants of those ancient Lepidoptera in which a jugum was developed constitute the suborder *Jugatæ;* while the descendants of those in which a frenulum was developed constitute the suborder *Frenatæ.*

We know but little of the Jugatæ, as nearly all of them have perished. There remain only two small families, the Hepialidæ and the Micropterygidæ. But these families are very widely separated, and hence it is safe to assume that they are the remnants of what was in past times a large fauna.

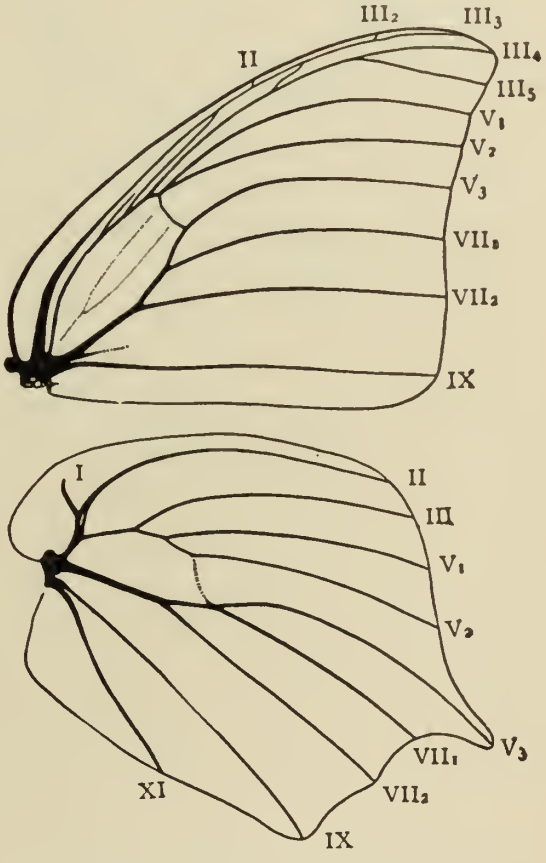

FIG. 241.—Wings of *Anæa andria.*

In the Frenatæ, however, there exist to-day many families, each exhibiting its own methods of specialization.

In some of these families the frenulum has been preserved and perfected to a greater or less extent. But in others a curious change has taken place.

It is obvious that if the two wings of each side overlap to a great extent, their acting together will be assured by this fact. And this is

what has taken place with the butterflies, the skippers, and certain moths. With these insects the humeral angle of the hind wing has been greatly enlarged, so that it projects far beneath the fore wing (Fig. 241). When this has taken place there is no longer any need of a frenulum, and consequently this organ is no longer preserved by natural selection. We find, therefore, that several families of Lepidoptera that belong to the suborder Frenatæ, being descendants of

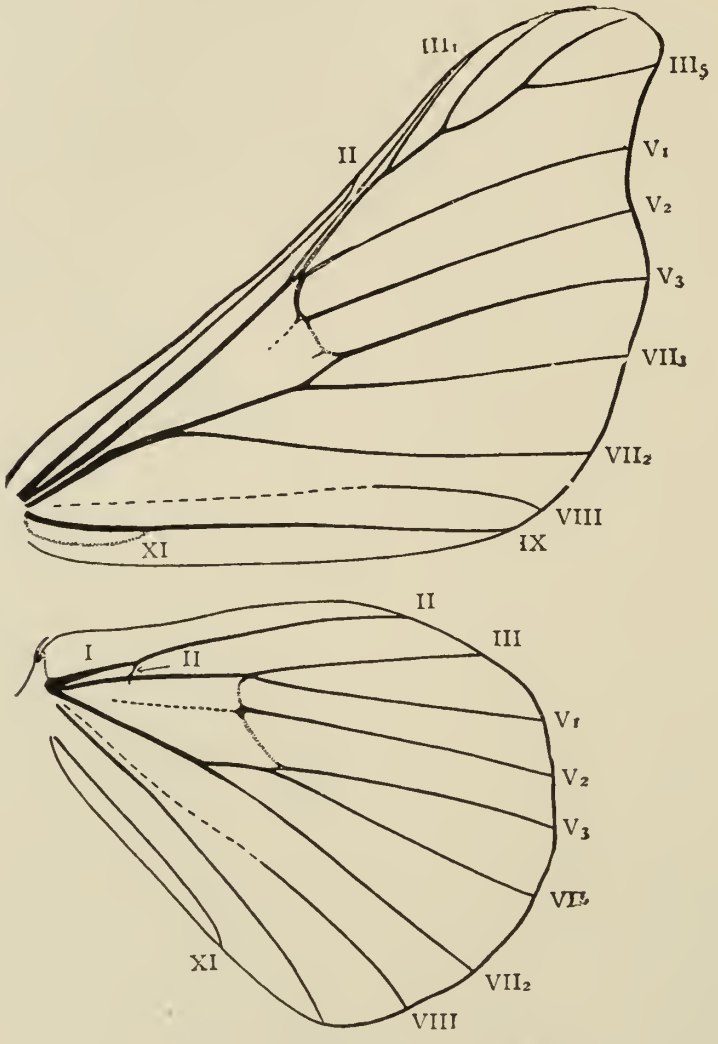

FIG. 242.—Wings of *Bombyx mori*.

ancient frenulum-bearing moths, no longer possess a frenulum. These are classed in the following synopsis as the frenulum-losers. It is a very interesting fact, and one that bears out the theory just stated, that in the more generalized of the frenulum-losing moths, as the Bombycidæ, the frenulum has not yet entirely disappeared, but is preserved in a rudimentary state (Fig. 242). We place the frenulum-losers last in a serial arrangement of the fami-

lies of Lepidoptera, regarding them as those that depart most widely from the primitive type.

From the foregoing it will be seen that a study of the relation to each other of the fore and hind wings gives us important hints as to the probable courses development has taken in the different families. Equally suggestive hints may be derived from a study of the venation of the wings.

By an extended study of fossil forms and the more generalized of living forms, the details of which study cannot be given here,* it has been determined that in the primitive Lepidoptera vein V of both fore and hind wings was well developed, and extended from the base of the wing out through the discal cell. We find that in certain families of existing moths this vein is still preserved (see p. 65), while in others it has been lost. Those families of the Frenatæ in which it is best and most uniformly preserved are grouped together as the *Generalized Frenatæ* (see the following synopsis), while those in which it is lost or nearly so are considered more specialized.

With the loss of the base of vein V there occurs a connection of its branches with veins III and VII, so that in the more specialized forms these branches of vein V appear to be branches of those veins (Fig. 241). A study of the extent to which this change has gone gives much aid in determining the zoological position of the different genera and families. In certain families vein V_2 tends to become united to vein III; in others it tends to become united to vein VII. This too is an important character, of which use is made in the following synopsis.

The number of anal veins is another character the study of which throws much light on the relative position of the different forms. It has been determined that the ancient Lepidoptera had at least three anal veins in both fore and hind wings. This number has been preserved in one or both pairs of wings of the more generalized of living moths, but has been reduced to two or even to one in the more specialized families.

Enough has been said, without going into further details here, to show that the way to determine the relationships of organized beings is to determine the primitive form of their organs and the changes that have been brought about in these organs by the action of natural

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* The data upon which these conclusions are based are given at greater length in an essay, by the senior author, entitled *Evolution and Taxonomy*. This essay forms a part of the Wilder Quarter-Century Book, published by the Comstock Publishing Company, Ithaca, N. Y.

selection. The classification of animals and plants should not be merely the assorting of them into convenient pigeon-holes, but a serious study of their blood-relationships.

The following synopsis will serve to show what we believe to be the relations of the principal divisions of the order. Following this synopsis there is a table for use in classifying specimens.

SYNOPSIS OF THE LEPIDOPTERA.

(*See page* 207 *for a table for determining specimens.*)

A. THE JUGATE LEPIDOPTERA.—Moths in which the two wings of each side are united by a *jugum* (Fig. 238, *j*), p. 214.

Suborder JUGATÆ.

B. The Swifts or *Macrojugatæ*, p. 215.....Family HEPIALIDÆ.

BB. The Little-wing Jugates or *Microjugatæ*, p. 216.

Family MICROPTERYGIDÆ.

AA. THE FRENATE LEPIDOPTERA.—Moths, skippers, and butterflies in which the two wings of each side are united by a *frenulum* (Fig. 237, *f*) or by its substitute, a large humeral angle of the hind wing (Fig. 241), p. 201.....Suborder FRENATÆ.

B. THE GENERALIZED FRENATÆ.—Moths that are supposed to retain more nearly than any other Frenatæ the form of the primitive Frenatæ, those that were the first to appear on earth. In these generalized moths the wings approach the typical form; the base of vein V of one or both pairs of wings is preserved throughout a considerable part at least of the discal cell; and the anal veins are well preserved, there being two or three in the fore wing and three in the hind wing. The frenulum is usually well preserved.

The Flannel-moths, p. 218.....Family MEGALOPYGIDÆ.

The Bag-worm Moths, p. 219.....Family PSYCHIDÆ.

The Carpenter-moths, p. 221.....Family COSSIDÆ.

The Slug-caterpillar Moths, p. 223.....Family EUCLEIDÆ.

The Smoky-moths, p. 226.....Family PYROMORPHIDÆ.

BB. THE SPECIALIZED FRENATÆ.—Moths, skippers, and butterflies that depart more widely than do the Generalized Frenatæ from the primitive type of Lepidoptera, being more highly modified for special conditions of existence. An indication of the specialized condition of these insects is the modified form of the wings. In nearly all the base of vein V has been lost and the branches of this vein joined to veins III and VII.

C. THE MICROFRENATÆ.—Frenulum-bearing moths, which are usually of small, often minute, size. The anal area of the hind wings is not reduced, having usually three anal veins except in certain minute forms where a broad fringe has been substituted for the membrane of this area.

The Pyralids, p. 228.....Superfamily PYRALIDINA.
The Tortricids, p. 239.....Superfamily TORTRICINA.
The Tineids, p. 246.....Superfamily TINEINA.
The Clear-winged Moths, p. 259.....Family SESIIDÆ.

CC. THE SPECIALIZED MACROFRENATÆ.—Specialized Frenatæ which are usually of medium or large size. This division includes certain moths and all skippers and butterflies. In these insects the anal area of the hind wing is reduced, containing only one or two anal veins.

D. *The Frenulum-conservers.*—Specialized Macrofrenatæ in which the two wings of each side are united by a frenulum. This group includes only moths.

E. Moths that appear to have a three-branched cubitus, only vein V_3 being closely connected with vein VII. Vein V_2 either retains its primitive position midway between veins III and VII or arises from the discal vein nearer to vein III than to vein VII.*

The Dioptids, p. 262.....Family DIOPTIDÆ.
The Prominents, p. 263.....Family NOTODONTIDÆ.
The Measuring-worm Moths, p. 270.
Superfamily GEOMETRINA.

EE. Moths that appear to have a four-branched cubitus, the base of vein V_2 of one or both pairs of wings being more closely connected with vein VII than with vein III.

F. Moths in which the humeral angle of the hind wings is greatly extended, but which as a rule possess the frenulum in one sex at least.

The Auzatids, p. 288.....Family AUZATIDÆ.
The Hook-tip Moths, p. 289.....Family DREPANIDÆ.

FF. Moths in which the humeral angle of the hind wings is not greatly extended.

G. *The Noctuids and their Allies.*—Moths in which some of the branches of vein III of the fore wings coalesce

* In many Hawk-moths vein V_2 nearly or quite retains its primitive position; but when it has moved from this position, it is nearer to vein VII than to vein III. This family is placed, therefore, in the next division (EE) of this synopsis.

beyond the discal cell, and which do not have what appears to be a cross vein between veins II and III of the hind wings.

The Cymatophorids, p. 291. Family CYMATOPHORIDÆ.
The Owlet-moths, p. 293.....Family NOCTUIDÆ.
The Tussock-moths, p. 308....Family LYMANTRIIDÆ.
The Wood-nymph Moths, p. 313. Family AGARISTIDÆ.
The Pericopids, p. 316..... Family PERICOPIDÆ.
The Tiger-moths, p. 317.....Family ARCTIIDÆ.
The Footman-moths, p. 324 ....Family LITHOSIIDÆ.
The Zygænids, p. 326.....Family ZYGÆNIDÆ.

GG. *The Window-winged Moths.*—Moths in which vein III of the fore wings is five-branched and in which all of these branches arise from the discal cell (Fig. 404), p. 328.....Family THYRIDIDÆ.

GGG. *The Hawk-moths.*—Moths in which there appears to be a cross vein between veins II and III of the hind wings (Fig. 407), p. 330.....Family SPHINGIDÆ.

DD. *The Frenulum-losers.*—Specialized Macrofrenatæ, in which the frenulum has been supplanted by a greatly extended humeral area of the hind wings. In some of the more generalized forms a rudimentary frenulum persists (Bombycidæ and Lacosomidæ). This division includes three groups of families: the Frenulum-losing Moths, the Skippers, and the Butterflies. The grouping together of the families included in this division is merely provisional, as it is probable that the loss of the frenulum has arisen independently in several of them.

E. *The Frenulum-losing Moths.*—In these moths the antennæ are usually pectinate; they are never enlarged into a club at the tip.

F. Moths with cubitus of the fore wings apparently three-branched.

G. Moths in which veins III_3 and III_4 coalesce to a great extent. The Saturnians. p. 339.
Superfamily SATURNIINA.

GG. Moths in which veins III_3 and III_4 do not coalesce beyond the discal cell. p. 357..Family LACOSOMIDÆ.

FF. Moths in which cubitus of the fore wings is apparently four-branched. p. 359.....Family LASIOCAMPIDÆ.

EE. *The Skippers.*—These are day-flying Lepidoptera which resemble butterflies in usually holding their wings erect

when at rest, but are distinguished by the peculiar venation of the fore wings, vein III being five-branched, and all the branches arising from the discal cell. The antennæ are enlarged into a club towards the tip. p. 364.

Superfamily HESPERIINA.

EEE. *The Butterflies.*—Day-flying Lepidoptera that hold their wings erect when at rest, that have clubbed antennæ, and that differ from the Skippers in the venation of the fore wings, some of the branches of vein III coalescing beyond the discal cell.....Superfamily PAPILIONINA.

F. Butterflies in which vein VII is apparently four-branched. The Swallow-tail Butterflies. p. 375.

Family PAPILIONIDÆ.

FF. Butterflies in which vein VII is apparently three-branched.

G. Butterflies exhibiting no tendency to abortion of the fore legs.

The Pierids. p. 381.....Family PIERIDÆ.

GG. Butterflies exhibiting a marked tendency to abortion of the fore legs.

The Gossamer-winged Butterflies. p. 388.

Family LYCÆNIDÆ.

The Brush-footed Butterflies. p. 395.

Family NYMPHALIDÆ.

TABLE FOR DETERMINING THE PRINCIPAL GROUPS OF LEPIDOPTERA.

A. Wingless or with rudimentary wings. This division includes only females. All males of Lepidoptera are winged.

B. The larvæ case-bearers; the adult female remaining within the case to lay her eggs. p. 219.....PSYCHIDÆ.

BB. The larvæ not case-bearers; the wingless adult not in a case.

C. The adult remaining upon her cocoon to lay her eggs; the body of the adult clothed with fine hairs. p. 308.

LYMANTRIIDÆ.

CC. The adult active, laying her eggs remote from her cocoon; the body of the adult clothed with flattened scales. p. 270.

GEOMETRINA.

AA. Winged, fore and hind wings similar in form and venation, the radius of the hind wings being, like that of the fore wings, five-branched. (Fig. 238.) (Suborder *Jugatæ*.) [See also AAA.]

B. Moths of medium or large size. p. 215.....HEPIALIDÆ.

BB. Minute moths, resembling Tineids in appearance. p. 214. MICROPTERYGIDÆ.

AAA. Winged, fore and hind wings differing in form and venation; the radius of the hind wings being simple, although frequently apparently two- or three-branched; this is due to the union of one or two branches of media with it (Figs. 241, 242). (Suborder *Frenatæ*.)

B. Antennæ of various forms, but never thread-like with a knob at the extremity* (moths in part).

C. The fringe on the inner angle of the hind wings as long as, or longer than, the width of the wing; the hind wings often lanceolate, but never fissured. p. 246.....TINEINA.

CC. The fringe on the hind wings shorter; the hind wings not lanceolate.

D. Wings fissured.

E. Each wing divided into six lobes. p. 238...ORNEODIDÆ.

EE. Wings never more than four-lobed; usually the fore wings are bilobed and the hind wings trilobed. p. 237. PTEROPHORIDÆ.

DD. Wings not fissured.

E. Fore wings very narrow, the width at the middle less than one fourth the length of the wing; a considerable part of the hind wings, and in many cases of the fore wings also, free from scales. p. 259.....SESIIDÆ.

EE. Wings scaled throughout, or if clear with the fore wings triangular in outline.

F. Hind wings with three anal veins. Care must be taken not to mistake a mere fold in the wing for a vein. When there is no thickening of the membrane of the wing along a fold it is not counted as a vein.

G. Subcosta and radius of the hind wings grown together for a greater or less distance between the apex of the discal cell and the apex of the wing, or in some cases separate but very closely parallel. p. 228..PYRALIDINA.

GG. Subcosta and radius of the hind wings widely separate beyond the apex of the discal cell.

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* In some moths the antennæ are enlarged towards the tip, forming a more or less distinct club; but this club is quite different in shape from the knob at the extremity of the antennæ in the skippers and the butterflies. In the moths with club-like antennæ the ocelli are usually present, and the hind wings bear a frenulum.

H. Microlepidoptera; *i.e.*, moths that are in most cases of small or minute size; with those included here the palpi are well developed, often prominent—when the palpi are not prominent the antennæ are at least as long as the front wings; the fringe on the anal angle of the hind wings is considerably longer than elsewhere.

I. The second anal vein of the *hind* wings forked towards the base. p. 239.....TORTRICINA.

II. The second anal vein of the *hind* wings not forked towards the base. p. 246.....TINEINA.

HH. Macrolepidoptera; *i.e.*, moths usually of medium or large size. With those included here the palpi are small, rarely projecting beyond the head; the antennæ are of moderate length; and the fringe on the anal angle of the hind wing is not longer than elsewhere, or but slightly so.

I. Subcosta and radius of hind wings grown together to near the end of the discal cell. (Fig. 267.)

J. Small black moths, with thinly scaled wings. p. 226..... .....PYROMORPHIDÆ.

JJ. Moths of medium size, and densely clothed with long woolly hairs, which are light colored or brown. p. 218 .....MEGALOPYGIDÆ.

II. Subcosta and radius of hind wings distinct or grown together for only a short distance.

J. Anal veins of the fore wings anastomosing so as to appear as a branched vein (Fig. 253). p. 219.....PSYCHIDÆ.

JJ. Anal veins of fore wings not forked outwardly.

K. Vein V_2 of the fore wings arising from the discal cell nearly midway between veins V_1 and V_3.

L. Vein V_3 of both fore and hind wings coalescing with vein VII_1 for a considerable distance beyond the end of the discal cell (Fig. 309). p. 262.....DIOPTIDÆ.

LL. Veins V_3 and VII_1 not coalescing beyond the end of the discal cell.

M. Veins III_2 and III_3 coalesced at base, but separate from veins III_4 and III_5.

which also coalesce (Fig. 438). p. 357. LACOSOMIDÆ.

MM. Veins III_2, III_3, III_4, and III_5 united at base (Fig. 419). p. 340..BOMBYCIDÆ.

KK. Vein V_2 of the fore wings emerging from the discal cell nearer to cubitus than to radius, causing cubitus to appear four-branched.

L. Fore wings with an accessory cell (Fig. 255); veins III_2 and III_3 coalesced at base, also veins III_4 and III_5; the accessory cell is formed by the anastomosing of veins III_3 and III_{4+5}. p. 221.....COSSIDÆ.

LL. Fore wings without an accessory cell; veins III_3 and III_4 coalescing to a greater extent than any other branches of radius (Fig. 261). p. 223.....EUCLEIDÆ.

FF. Hind wings with less than three anal veins.

G. Fore wings with two distinct anal veins or with the anal veins partially grown together in such a way as to appear as a single branched vein.

H. Anal veins of fore wings partially grown together so as to appear as a branched vein (Fig. 253). p. 219 PSYCHIDÆ.

HH. Fore wings with two distinct anal veins. p. 226. PYROMORPHIDÆ.

GG. Fore wings with a single fully preserved anal vein. This is the second anal vein (vein IX); the first anal vein (vein VIII) is absent or represented merely by a fold; and the third anal vein (vein XI) is short, not reaching to the margin of the wing, or is wanting; usually when the third anal vein is present it is joined to the second anal vein, so that the latter appears to be forked towards the base.

H. Frenulum present. In most cases the humeral angle of the hind wings is not largely expanded.

I. The five branches of radius and the three branches of media of the fore wings present, and each one arising from the discal cell (Fig. 404). Small moths (the largest expanding only three fourths inch) resembling Hawk-moths in form, and with translucent spots on their wings. p. 328. THYRIDIDÆ.

II. Some of the branches of radius or of media either wanting or grown together beyond the discal cell.

J. Hind wings with subcosta and radius apparently distinct but connected by a strong oblique cross vein (Fig. 407). Moths of medium or large size, with spindle-shaped bodies, narrow, strong wings, and usually with the antennæ prismatic in form, and more or less thickened in the middle or towards the tip, which is frequently recurved in the form of a hook (Hawk-moths). p. 329.....SPHINGIDÆ.

JJ. Subcosta and radius of hind wings either distinct or grown together; but not appearing to be connected by a strong, oblique cross vein.

K. Vein V_2 of the fore wings not more closely joined to cubitus than to radius, cubitus being apparently three-branched.

L. The basal part of the subcosta of the hind wings extending from the base towards the apex of the wing in a regular curve. Moths resembling Noctuids in form; *i.e.*, with a large abdomen and with rather narrow, strong, and coarsely-scaled fore wings.

M. Vein V_2 of the hind wings arising much nearer to cubitus than to radius; vein V_1 of the hind wings joined to radius at a considerable distance before the apex of the discal cell (Fig. 349). p. 291.
CYMATOPHORIDÆ.

MM. Vein V_2 of the hind wings either wanting or present, but when present arising either midway between radius and cubitus, or nearer to radius than to cubitus; vein V_1 of the hind wings joined to radius at or beyond the apex of the discal cell (Fig 311). p. 263.
NOTODONTIDÆ.

LL. The basal part of the subcosta of the hind wings joined to radius for a considerable distance and then making a prominent bend towards the costal margin, as in *Cicin-*

nus (Fig. 438). Veins III_3 and III_4 of the fore wings separate from each other. p. 357. [See also LLL.]..... .....LACOSOMIDÆ.

LLL. The basal part of the subcosta of the hind wings making a prominent bend into the humeral angle of the wing (Fig. 327); veins III_3 and III_4 coalesced to near the apex of the wing. In most cases, moths with a slender abdomen, and with rather broad, delicate wings, which are finely scaled. p. 270.....GEOMETRINA.

KK. Vein V_2 of the fore wings more closely joined to cubitus than to radius; cubitus being in most cases apparently four-branched.

L. Small moths with the apex of the fore wings sickle-shaped. p. 289..DREPANIDÆ.

LL. Apex of the fore wings not sickle-shaped.

M. Small moths with snow-white wings, in which the subcosta of the hind wings extends distinct from radius to a point beyond the discal cell where the two are united for a greater or less distance (Fig. 344). p. 288.....AUZATIDÆ.

MM. The subcosta of the hind wings extending distinct from the radius, or the two joined for a very short distance, near the base of the wing. [See also MMM.]

N. Chiefly day-flying moths that are either black with large, white or yellow, rounded patches upon the wings, or have the front wings white, margined with brown, and the hind wings pale yellow.

O. Cubitus of hind wings apparently four-branched (Fig. 384). p. 316. PERICOPIDÆ.

OO. Cubitus of hind wings apparently three-branched (Fig. 379). p. 313. AGARISTIDÆ.

NN. Not such moths as are described under N.

O. Antennæ pectinate.

P. Ocelli absent. p. 308.

LYMANTRIIDÆ.

PP. Ocelli present. p. 293 NOCTUIDÆ.

OO. Antennæ simple. p. 293. NOCTUIDÆ.

MMM. The subcosta of the hind wings united with the radius for a considerable distance (*i.e.*, for one fifth or more of the length of the discal cell).

N. The subcosta and radius of the hind wings united for a considerable distance, but usually separating before the apex of the discal cell.

O. Ocelli present. p. 317...ARCTIIDÆ.

OO. Ocelli absent. p. 324..LITHOSIIDÆ.

NN. The subcosta and radius of the hind wings united into a single vein (Fig. 399), or at most with their tips separate near the apex of the wing. With all the moths included under this head and under the preceding N, vein V_1 of the hind wings is present and is joined to radius at or near the apex of the discal cell; care should be taken not to mistake this vein V_1 for radius, p. 326.....ZYGÆNIDÆ.

HH. Frenulum absent; the humeral angle of the hind wings largely expanded and serving as a substitute for a frenulum.

I. Cubitus of both wings apparently four-branched, due to the fact that both the second and third branches of media (V_2 and V_3) are joined to it.

J. Small moths, with slender bodies, and with the apex of the fore wings sickle-shaped; humeral veins absent. p. 289.....DREPANIDÆ.

JJ. Moths of various sizes, but with robust bodies, and with the apex of the fore wings not sickle-shaped; hind wings with humeral veins. p. 359..... .....LASIOCAMPIDÆ.

II. Cubitus of both fore and hind wings apparently three-branched, due to the fact that only the third branch of media (V_3) is more closely joined to it than to radius. (The moths included in this

section of this table are robust, with strong wings, and are of medium or large size. In some of the Geometrina (p. 270), which also have a three-branched cubitus, the frenulum is inconspicuous or even in rare cases (*Dyspteris*) wanting; these moths can be distinguished from those included here by their smaller size, more slender body, and weaker wings). p. 339.....SATURNIINA.

BB. Antennæ thread-like with a knob at the extremity.

C. With the radius of the fore wings five-branched, and with all of the branches arising from the discal cell (Fig. 445); club of antennæ usually terminated by a recurved hook. *The Skippers*, p. 364.....HESPERIINA.

CC. With some of the branches of the radius of the fore wings coalesced beyond the apex of the discal cell (Fig. 455); club of antennæ not terminated by a recurved hook. *The Butterflies*. p. 373.....PAPILIONINA.

Suborder JUGATÆ (Ju-ga'tæ).

The Jugate (Ju'gate) Lepidoptera.

The American representatives of this suborder are rare moths, which the student beginning the study of insects is not likely to meet. They can be easily recognized by the peculiar structure of the hind wings, which resemble the fore wings in form and in venation (Fig. 238). In all other Lepidoptera, the two pairs of wings differ in form, and the hind wings are furnished with fewer veins than are the fore wings.

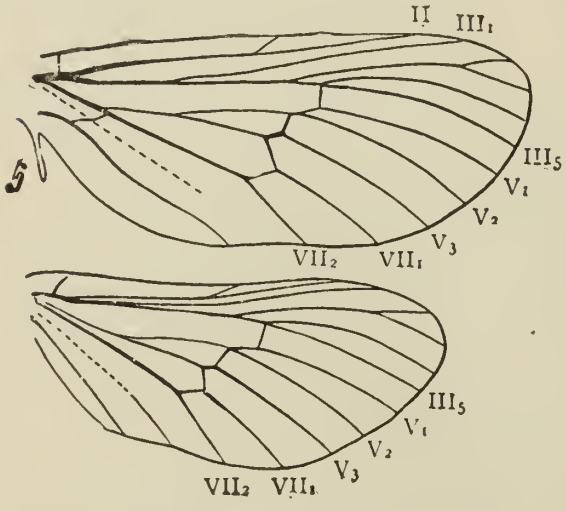


FIG. 243.—Wings of *Hepialus gracilis*.

The most important characteristic of the suborder, and the one to which its name refers, is the way in which the two wings of each side are fastened together. There projects backward from the inner margin of the fore

wing near its base a small lobe (Fig. 243,*j*), which extends under the costal margin of the hind wing; while the greater part of the inner margin of the fore wing overlaps the hind wing. This arrangement assures the acting together of the two wings.

This projecting lobe is named the *jugum* or yoke; and the moths possessing this organ are termed the Jugatæ or the Jugate Lepidoptera.

This suborder includes only two families; one represented by minute moths, the other by moths of medium or large size.

Family HEPIALIDÆ (He-pi-al'i-dæ).

The Swifts.

The members of this family are of medium or large size. Figure 244 represents one of the larger species. Our best

FIG. 244.—*Hepialus argenteomaculatus.*

known forms are brown or ashy gray in color, with the wings marked with silvery white spots.

It is said that these moths fly near the earth, and only in the evening after sunset, hiding under some low plant, or clinging to the stalk of an herb during the day. Some of them fly with extreme rapidity, with an irregular mazy flight, and have, therefore, been named Swifts by collectors. They are attracted to lights. Figure 238 represents the venation of the wings of *Hepialus* (He-pi'a-lus).

The larvæ are nearly naked, and grub-like in appearance, although furnished with sixteen legs. They feed upon wood, and are found at the roots or within the stems of plants. They transform either in their burrows, or, in the case of those that feed outside of roots, within loose cocoons. The pupæ have transverse rows of teeth on the abdominal segments; these aid them in emerging from their burrows. The best known American species bores in the stems of the speckled or hoary alder (*Alnus incana*).

Family MICROPTERYGIDÆ (Mi-crop-te-ryg'i-dæ).

The Little-winged Jugates (*Ju'gates*).

These are very minute moths, which resemble Tineids in size and appearance. The largest species known to the writer expands but little more than half an inch. Figure 245 represents the venation of the wings. Only a single genus,

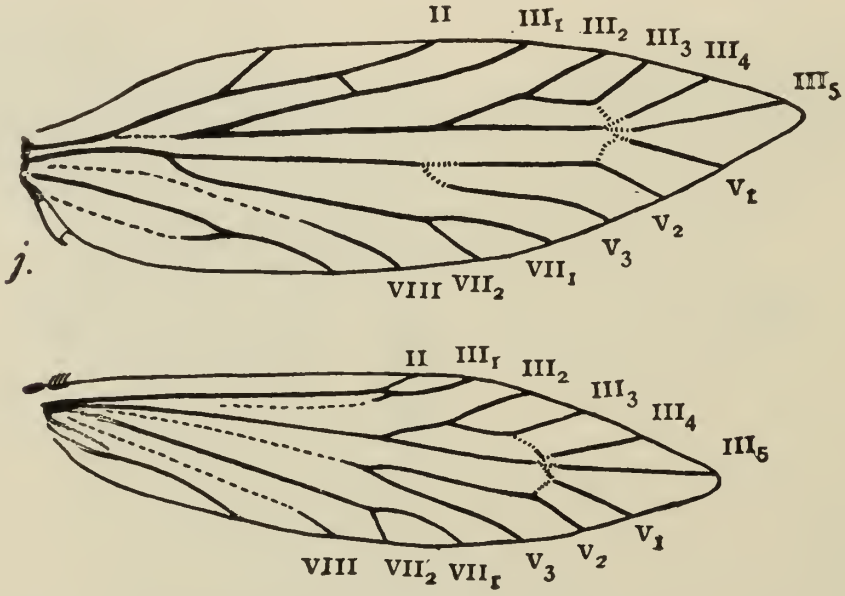


FIG. 245.—Wings of *Micropteryx*.

Micropteryx (Mi-crop'te-ryx), occurs in this country. The larvæ are leaf-miners.

Suborder FRENATÆ (Fre-na'tæ).

The Frenate (*Fre'nate*) *Lepidoptera.*

To the Frenatæ belong nearly all of our moths, and all skippers and butterflies. With most moths of this suborder

there exists near the base of the costal margin of the hind wings a strong bristle or bunch of bristles named the *frenulum*, or little bridle (Fig. 237, *f*). As the frenulum projects forward under the fore wing it tends to depress the hind wing when the fore wing is depressed, thus insuring the acting together of the two pairs of wings. Usually the frenulum consists of two or more bristles in females and of a single stronger bristle in males. The difference is due to the fact that in males the bunch of bristles have grown together into a single strong bristle. There is also another sexual difference. In the males the tip of the frenulum fits into a membranous hook borne on the lower surface of the fore wing, thus firmly tying together the two wings (Fig. 237, *f*. *h*). This frenulum hook is rarely found in females. In certain moths there is, besides the frenulum hook, a tuft of hairs projecting forwards from just behind the cubitus of the fore wing near its base, which tends also to keep the frenulum in place.

With some moths and with all skippers and all butterflies the base of the costal portion of the hind wings, the *humeral angle* as it is termed, is largely developed, so that it projects far under the fore wing (Fig. 241). This overlapping of the two wings at the base to so great an extent insures their acting together without the aid of the frenulum; and, consequently, there being no use for a frenulum, this organ has disappeared. In other words, the frenulum has been superseded by the large development of the humeral angle. But as we believe that these moths, skippers, and butterflies have descended from forms which had a frenulum, we class them with the moths that still possess this organ under the suborder Frenatæ.

A more easily observed character which serves to distinguish members of this suborder is a striking difference in the venation of the two pairs of wings, the hind wings having fewer veins than the fore wings.

Family MEGALOPYGIDÆ (Me-gal-o-pyg'i-dæ).

The Flannel-moths.

Sometimes there is attracted to our evening lamp a whitish moth, whose wings, being densely clothed with long curly hairs, resemble bits of flannel; this is the Crinkled Flannel-moth, *Megalopyge crispata* (Me-gal-o-py'ge cris-pa'ta). It is cream-colored, with the fore wings marked with wavy lines of crinkled black and brownish hairs. The male is represented by Figure 246; the female is larger, expanding one and three fifths inches. In the female the antennæ are very narrowly pectinate. The larva is said to feed on oak, elm, apple, and raspberry.

FIG. 246.—*Megalopyge crispata.*

In the Southern States there occur three other species of this family. These moths are easily distinguished by the structure of their wings (Fig. 247). There are three anal veins in both fore and hind wings; but in the fore wings the second and third anal veins (veins IX and XI) are partially grown together. The basal part of vein V is more or less distinctly preserved, and divides the discal cell into two nearly equal parts. Veins II and III of the hind wings are grown together nearly to the end of the discal cell.

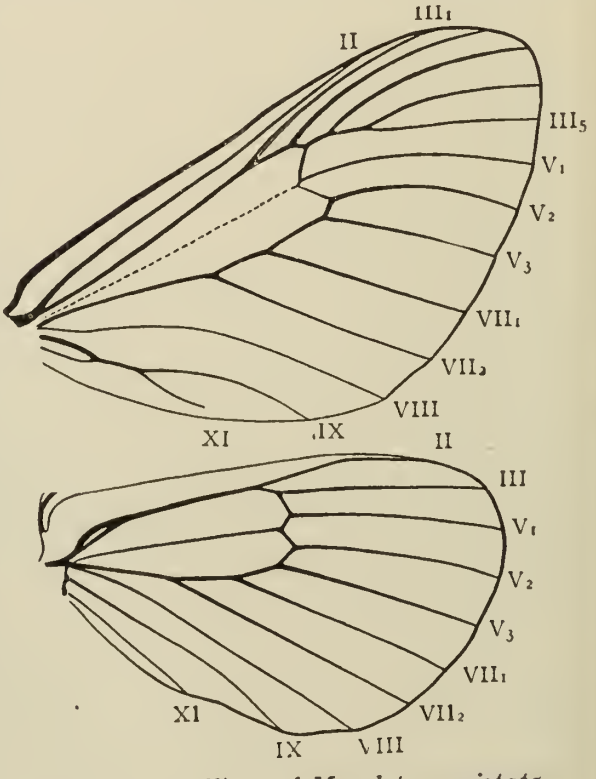


FIG. 247.—Wings of *Megalopyge crispata.*

The larvæ of the Flannel-moths are remarkable for the possession of ten pairs of legs, three thoracic and seven abdominal. All other known lepidopterous larvæ, except perhaps those of *Micropteryx*, have lost some of the abdominal legs. The cocoons of these insects are also remarkable, being furnished with a trap-door (Fig. 248).

FIG. 248.—Cocoon of *Megalopyge*.

Family PSYCHIDÆ (Psy'chi-dæ).

The Bag-worm Moths.

The Bag-worms are those caterpillars that have the curious habit of building each for itself a silken sac covered with little twigs within which it lives (Figs. 249 and 250). When the caterpillar wishes to move from one place to another it pushes forth the front end of its body and creeps along, carrying its house with it. It is said that the species that inhabit Ceylon are believed by the natives to be composed of individuals who in a previous incarnation were human beings and stole kindling-wood, and who now atone for the theft by repeating the act as an insect.

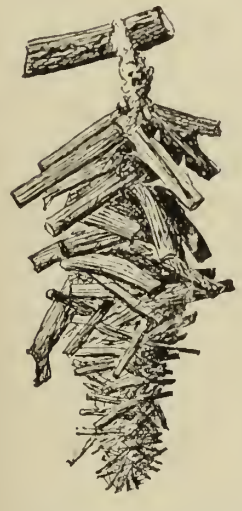


FIG. 249.—Bag of *Oiketicus abbotii*.

When a Bag-worm is fully grown, it fastens its sac to a twig and changes to a pupa within it. And here the females remain until death, leaving their eggs within their sacs. These females are grub-like creatures without wings. But the male pupa works his way out from the lower end of his sac and changes to a winged moth. Figure 250 represents the sac of a male with the empty pupa-skin projecting

FIG. 250.—Bag of *Psyche confederata*.

FIG. 251.—*Psyche confederata*.

from the lower end, and Figure 251 the fully developed male. These figures are of one of our smaller species, which belong to the genus *Psyche* (Psy'che).

Abbot's Bag-worm, *Oiketicus abbotii* (Oi-ket'i-cus ab-bot'i-i).—This species occurs in the more southern part of our country. The larva makes a bag with sticks attached to it crosswise (Fig. 249).

The Evergreen Bag-worm, *Thyridopteryx ephemeræformis* (Thyr-i-dop'te-ryx e-phem-e-ræ-for'-mis).—This is our best known species, and on this account has been commonly called The Bag-worm. But as it is desirable to have different names for the different species, we call this one the Evergreen Bag-worm; for although it feeds on many different trees, it prefers red cedar and arbor vitæ. The bag of this species is about the same size as that of Abbot's Bag-worm; but it differs in being covered with bits of leaves of cedar or arbor vitæ, or with twigs attached lengthwise.

FIG. 252.—*Thyridopteryx ephemeræformis.*

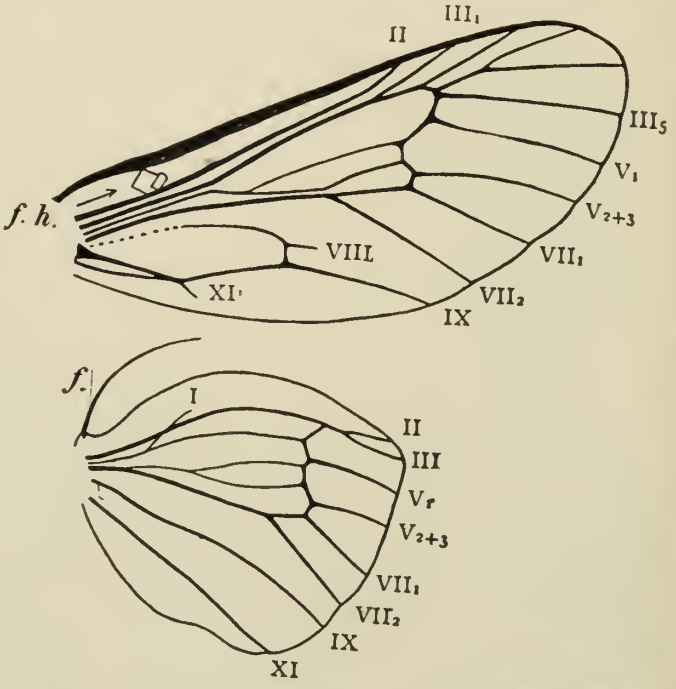


FIG. 253.—Wings of *Thyridopteryx ephemeræformis.*

The structure of the wings of the Psychidæ is very characteristic (Fig. 253). Both the fore and the hind wings may have either two or three anal veins; but the anal veins of the fore wings are grown together so as to appear as a single much-branched vein. The base of vein V is preserved and is forked

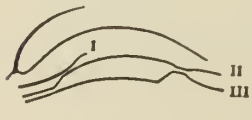


FIG. 254.

within the discal cell. In the hind wings, veins I and II and veins II and III are grown together in an unusual way. In Figure 254 these veins are represented slightly separated in order to show their relation to each other.

Family COSSIDÆ (Cos'si-dæ).

The Carpenter-moths.

This family includes moths with spindle-shaped bodies, and narrow, strong wings, some of the species resembling Hawk-moths quite closely in this respect. The larvæ are wood-borers, living in the solid wood of the trunks of trees. They are often very injurious to forest or shade trees, and one recently imported species is very injurious to pear trees. The wood-boring habits of the larvæ suggest the popular name Carpenter-moths for the insects of this family.

These moths fly by night, and lay their eggs on the bark

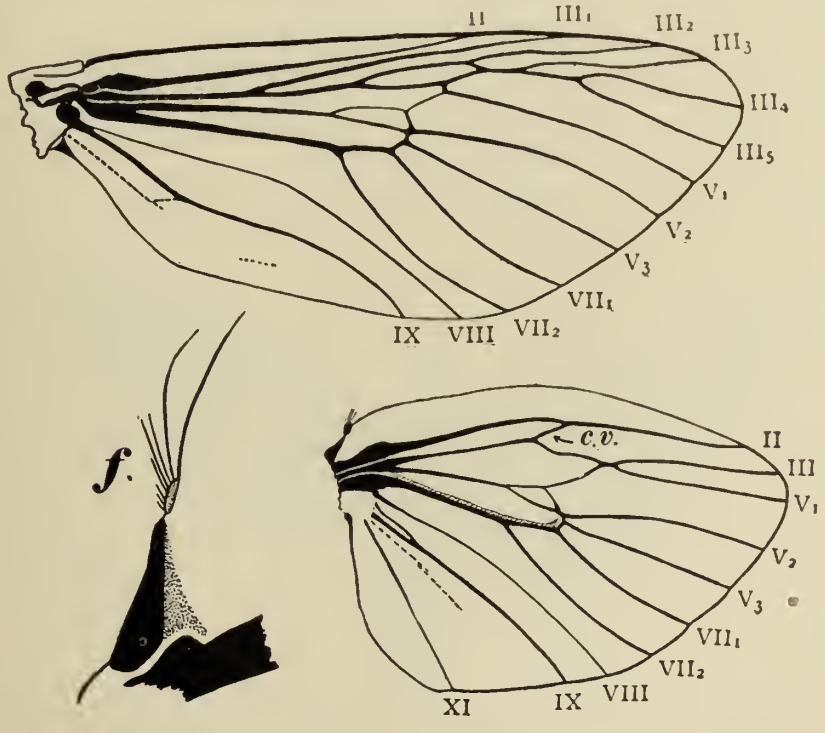


FIG. 255.—Wings of *Prionoxystus robiniæ*; *f*, frenulum, enlarged.

of trees, or within tunnels in trees from which adult Carpenter-moths have emerged. The caterpillars are nearly naked, and, although furnished with pro-legs as well as true legs, are grub-like in form. The pupa state is passed within

the burrow made by the larva. When ready to change to an adult, the pupa works its way partially out from its burrow. This is accomplished by means of backward-projecting, saw-like teeth, there being one or two rows of these on each abdominal segment. After the moths have emerged the empty pupa-skins can be found projecting from the deserted burrows.

The Carpenter-moths are of medium or large size. Our more common species are of a pepper-and-salt color, due to strongly contrasting dark and light scales. The antennæ are usually pectinate in both sexes, but in some species those of the female are simple; the ocelli are wanting; and the mouth-parts are obsolete.

The structure of the wings is shown in Figure 255 There are two anal veins in the fore wing, and three in the hind wings. The base of vein V is preserved, and is forked within the discal cell. In the fore wings, the branches of vein III anastomose so as to form an accessory cell. The frenulum is rudimentary in most of our genera (Fig. 255), but is strongly developed in others.

Our most common species is the Locust-tree Carpenter-

FIG. 256.—*Prionoxystus robiniæ.*

moth, *Prionoxystus robiniæ* (Pri-on-ox-ys'tus ro-bin'i-æ). Figure 256 represents the female natural size. The male is but little more than half as large as the female. It is much

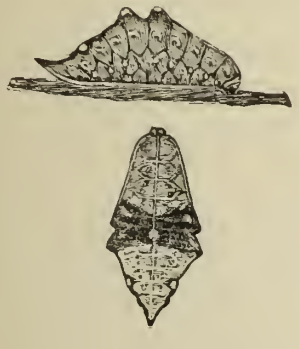
darker than the female, from which it differs also in having a large yellow spot, which nearly covers the outer half of the hind wings. This species flies in June and July. As suggested by its name, it infests locust; but its larva also bores in the trunks of oak, poplar, willow, and other trees. It is supposed that the species requires three years to complete its transformations.

The Leopard-moth, *Zeuzera pyrina* (Zeu-ze'ra py-ri'na) is a large European species which has become common in the vicinity of New York City, and will doubtless spread to other parts of the country. It is white, spotted with numerous small black spots. Its larva is very injurious, especially to maple. It infests other shade trees, and also apple and pear.

Family EUCLEIDÆ (Eu-cle'i-dæ).

The Slug-caterpillar Moths.

One often finds on the leaves of shrubs or trees elliptical or oval larvæ that resemble slugs in the form of the body and in their gliding motion. As these are larvæ of moths they have been termed Slug-caterpillars; but they present very little similarity in form to other caterpillars. The resemblance to slugs is greatly increased by the fact that the



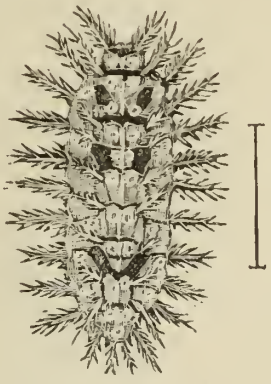


FIG. 257.—Larva of *Eulimacodes scapha*. FIG. 258.—*Euclea delphinii*, larva. FIG. 259.

lower surface of the body is closely applied to the object upon which the larva is creeping, the pro-legs being replaced by mere swellings on the abdominal segments. Some species are naked (Fig. 257); but many of them are armed

with branching spines (Fig. 258). The larvæ when full grown spin very dense cocoons of brown silk; these are egg-shaped or nearly spherical (Fig. 259), and are usually spun between leaves.

The moths are of medium or small size; they vary greatly in appearance, and many of them are very prettily colored.

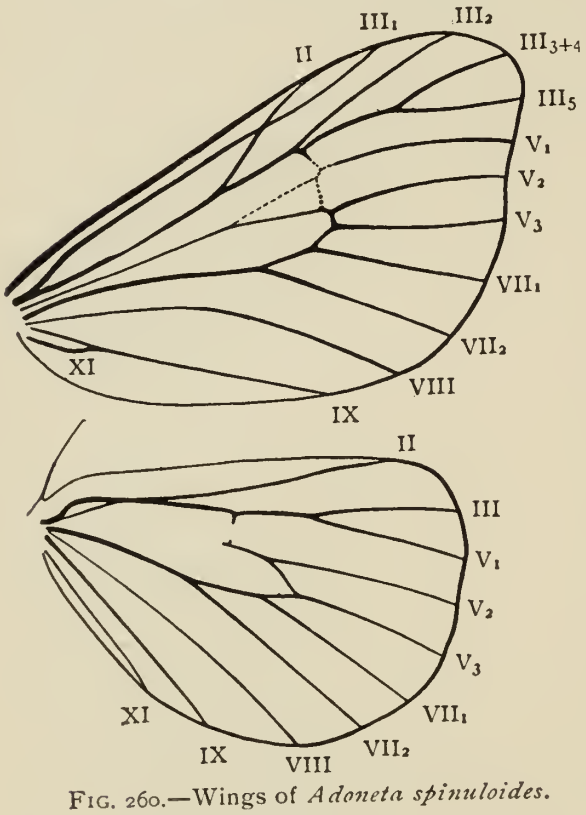


FIG. 260.—Wings of *Adoneta spinuloides*.

Considerable variation exists in the venation of the wings in this family (Figs. 260, 261). The base of vein V may be preserved or wanting. In some species it is forked within the discal cell, in others not. There is also considerable variation in the coalescence of the branches of radius, but veins III_3 and III_4 coalesce to a greater extent than any other branches of this vein, and there is no accessory cell.

The Skiff Caterpillar, *Eulimacodes scapha* (Eu-lim-a-co′des sca′pha).—This remarkable larva (Fig. 257) is not uncommon on oak and other forest trees. It is pale apple-green, with a chestnut-brown patch on its back. The moth (Fig. 262) is light cinnamon-brown, with a tan-brown triangular spot on each fore wing.

The Spiny Oak-slug, *Euclea delphinii* (Eu′cle-a delphin′i-i).—This larva (Fig. 258) is one of the most common of our slug-caterpillars. It feeds on the leaves of oak, pear, willow, and other trees. The moth is cinnamon-brown, with a variable number of bright green spots on the fore wings (Fig. 263).

The Saddle-back Caterpillar, *Empretia stimulea* (Em-pre'ti-a sti-mu'le-a).—This larva can be recognized by Figure 264. Its most characteristic feature is a large green

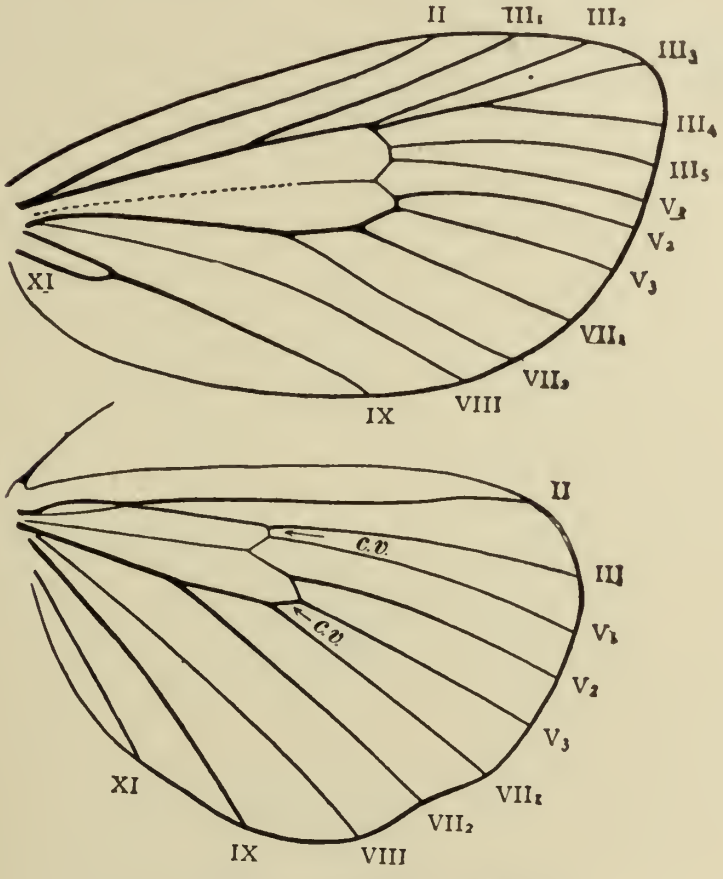


FIG. 261.—Wings of *Packardia geminata.*

patch on the back, resembling a saddle-cloth, while the saddle is represented by an oval purplish-brown spot. The moth is dark, velvety, reddish brown, with two golden dots

FIG. 262.—*Eulimacodes scapha.*

FIG. 263.—*Euclea delphinii.*

FIG. 264.—*Empretia stimulea*, larva.

near the apex of the fore wings. The larva feeds on oak and other forest trees. The prick of its spines is said to be venomous.

Family PYROMORPHIDÆ (Pyr-o-mor′phi-dæ).

The Smoky-moths.

There are but few insects in our country pertaining to this family. These are small moths, that are chiefly of a smoky black color; some are marked with brighter colors.

FIG. 265.—*Acoloithus falsarius.*

A tiny representative of the family which seems to be not uncommon in the East is *Acoloithus falsarius* (Ac-o-loi′thus fal-sa′ri-us). This moth (Fig. 265) expands two thirds of an inch. It is black, with the prothorax of an orange color. The venation of its wings (Fig. 266) is peculiar in that subcosta and radius of the hind wings coalesce for only a short distance beyond the middle of the discal cell, and a stump of radius projects towards the base of the wing, from the point of union of the two veins. The larva feeds in early summer on the leaves of grape and of the Virginia creeper. It is said that the pupa state lasts fourteen days and is passed within a parchment-like cocoon. The adult frequents flowers in the daytime.

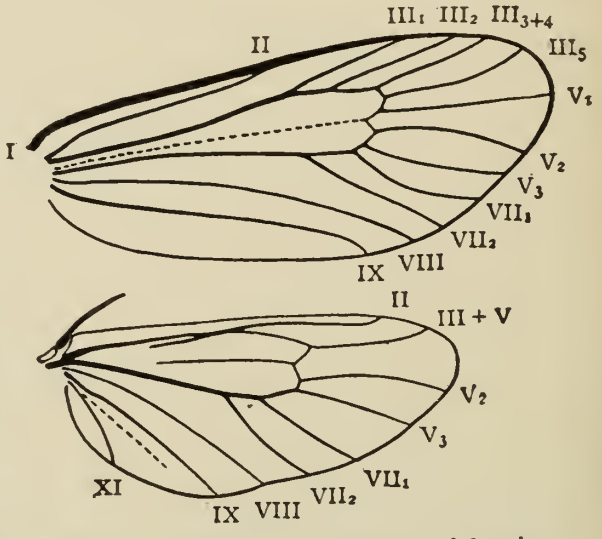


FIG. 266.—Wings of *Acoloithus falsarius.*

The typical genus of the family is represented in the Atlantic and Western States by *Pyromorpha dimidiata* (Pyr-o-mor′pha di-mid-i-a′ta). The entire insect is smoky black, except the basal half of the fore wings in front of vein IX, and the basal half of the costa of the hind wings, which are yellow. The wings are thinly scaled, and expand a little more than one inch. Figure 267 represents the venation of the wings.

In Texas and Arizona there occur several species of *Triprocris* (Trip'ro-cris). The venation of one of them is shown in Figure 268. It is remarkable in that none of the branches of radius of the fore wings coalesce beyond the discal cell.

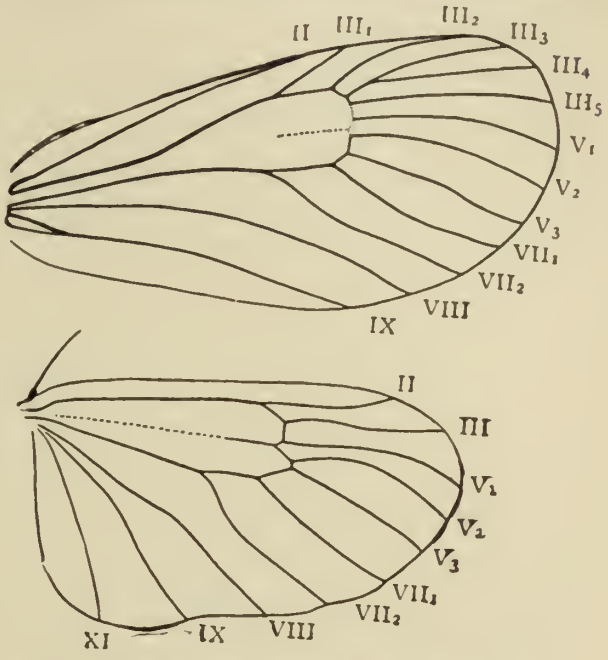


FIG. 267.—Wings of *Pyromorpha dimidiata.*

The genus *Harrisina* (Har-ris'i-na) seems to be closely allied to the preceding and is placed in this family provisionally. It differs, however, from the typical form of the family in that the anal area of the hind wings is greatly reduced, there being only two, short, strongly curved anal veins. As in the other members of the family there are two, well-developed anal veins preserved in the fore wings.

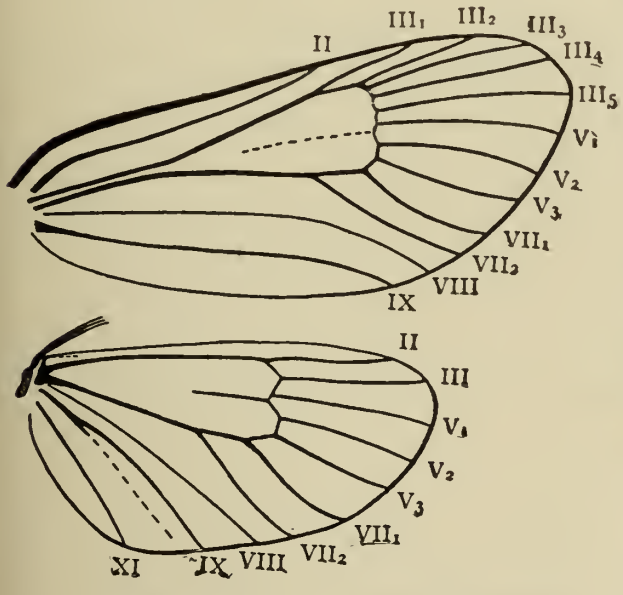


FIG. 268.—Wings of *Triprocris marteni.*

In the East the most common species is *Harrisina americana* (H. a-mer-i-ca'na) (Fig. 269).

FIG. 269.—*Harrisina americana.*

The wings are long and narrow; the abdomen is long and widened towards the caudal end. It is greenish black in color, with the prothorax reddish orange. The larva feeds

on the leaves of grape and of the Virginia creeper. An entire brood of these larvæ will feed side by side on a single leaf while young.

Harrisina texana (H. tex-a′na) occurs in the Southwest. It closely resembles the preceding; but is bluish black with a reddish orange prothorax. *Harrisina coracina* (H. cor-a-ci′na) also occurs in the Southwest. This species is entirely black.

Superfamily PYRALIDINA (Pyr-a-li-di′na).

The Pyralids (*Pyr′a-lids*).

This superfamily includes moths of medium or small size; but so large a proportion of the species are small that the superfamily is commonly classed with the two following as Microlepidoptera.

The members of the different families included in this superfamily differ so greatly in appearance that it is not possible to give a general description that will serve to distinguish it. It is necessary to study structural characters to find evidences of a common bond, and here as in other groups we find the structure of the wings most useful for this purpose.

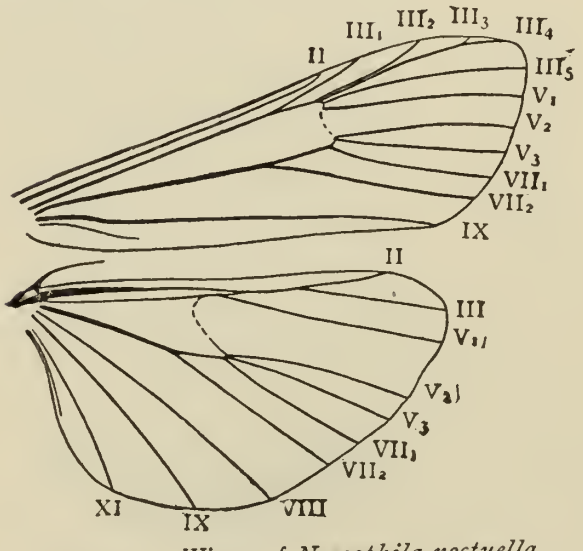


FIG. 270.—Wings of *Nomophila noctuella.*

As a rule there are three anal veins in the hind wings and two in the fore wings. In this respect this superfamily agrees with the preceding families and with the two following superfamilies. But in most cases the Pyralids can be recognized by the fact that the subcosta and radius of the hind wings are separate along the discal cell, but grown

together for a short distance beyond the cell, after which they are again separate (Fig. 270). In some genera these two veins do not actually coalesce, but extend very near together for a short distance (Fig. 271). The two types, however, are essentially the same.

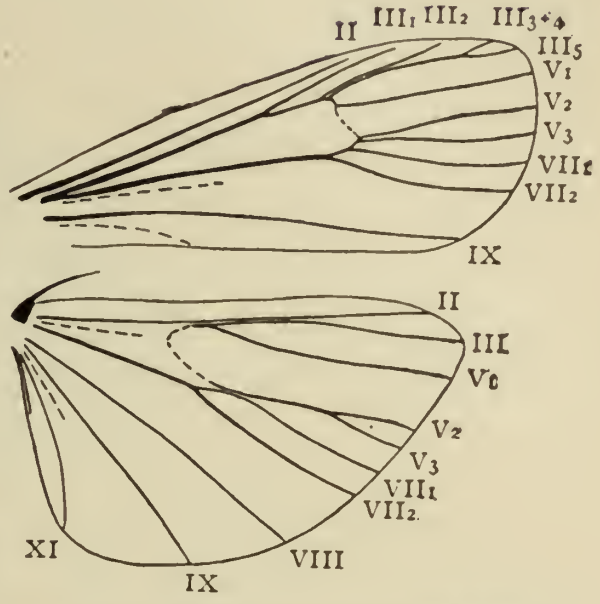


FIG. 271.—Wings of *Tlascala reductella*.

This superfamily includes seven families, which can be separated by the table given below. The Plume-moths are placed last in the series, as we believe that they depart more widely from the primitive type than do any of the other families.

A. Wings not fissured.

B. Hind wings without a fringe of hairs on the basal part of vein VII. Care must be taken not to mistake scattered hairs on the anal area of the wing for such a fringe.

C. Fore wings with veins III_4 and III_5 separate, vein III_5 arising from the discal cell (Fig. 272). p. 230.....PYRAUSTIDÆ.

CC. Fore wings with veins III_4 and III_5 united at base (Fig. 277). p. 232.....PYRALIDIDÆ.

BB. Hind wings with a fringe of long hairs on the basal part of vein VII.

C. Radius of fore wings five-branched.

D. Maxillary palpi more or less developed, but not triangular as in the next family. p. 233.....GALLERIIDÆ.

DD. Labial palpi long, straight, projecting forward; maxillary palpi well developed, strongly dilated at tip with scales, appearing triangular when viewed from the side. p. 234. CRAMBIDÆ.

CC. Radius of fore wings four-branched, veins III_3 and III_4 coalescing to edge of wing (Fig. 281). p. 235.....PHYCITIDÆ.

AA. Wings fissured.

B. Wings with less than five fissures; usually the fore wings have one fissure and the hind wings two. p. 237....PTEROPHORIDÆ.

BB. Each wing split into six parts. p. 238.... .....ORNEODIDÆ.

Family PYRAUSTIDÆ (Py-raus'ti-dæ).

The Pyraustids (*Py-raus'tids*).

The members of this family differ from other Pyralids by the following combination of characters. There is no fringe of long hairs on the basal part of vein VII of the hind wings, and vein III_5 of the fore wings arises from the discal cell distinct from vein III_4 (Fig. 272). This family includes many small moths; but it contains also the majority of the larger species of Pyralids. Some of the species are very striking in appearance.

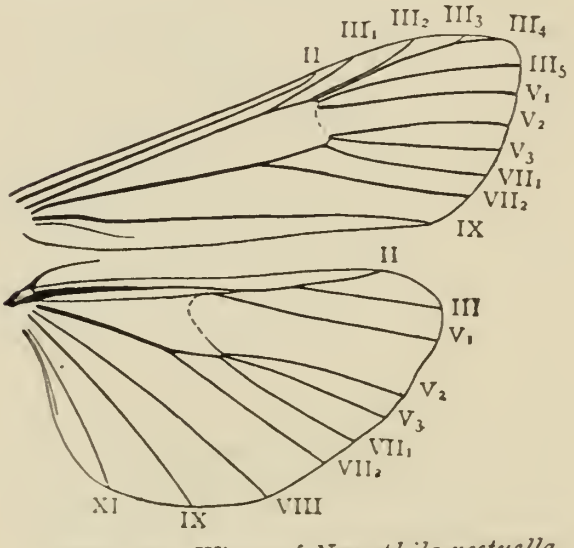


FIG. 272.—Wings of *Nomophila noctuella*.

The Grape Leaf-folder, *Desmia funeralis* (Des'mi-a fu-ne-ra'lis) is a common species, the larva of which feeds on the leaves of grape. The larva folds the leaf by fastening two portions together by silken threads. When full grown, it changes to a pupa within the folded leaf. The moth is black with shining white spots. The male (Fig. 273) differs from the female in having a knot-like enlargement near the middle of each antenna. There is some variation in the size and shape of the white spots on the wings. In some specimens the white spot of the hind wing is separated into two or three spots.

FIG. 273.—*Desmia funeralis*.

The Bass-wood Leaf-roller, *Pantographa limata* (Pan-tog′ra-pha li-ma′ta).—Our bass-wood trees often present a strange appearance from the fact that nearly every leaf is cut more than half way across the middle, and the end rolled into a tube (Fig. 274). Within this tube there lives a bright green larva, with the head and thoracic shield black. This larva resembles cer-

FIG. 274.—Nest of larva of *Pantographa limata.*

FIG. 275.—*Pantographa limata.*

tain Tortricid larvæ, both in appearance and habits; but a study of the adult shows it to be a Pyralid. The moth expands about one and one half inches; it is straw-colored, with many elaborate markings of olive with a purplish iridescence (Fig. 275). There is one brood a year; the winter is passed in the larval state.

The Melon-worm, *Margaronia hyalinata* (Mar-ga-ro′ni-a hy-a-li-na′ta).—This beautiful moth (Fig. 276) is often a serious pest in our southern states, where the larva is very

destructive to melons and other allied plants, destroying both the foliage and the fruit. The moth is a superb

FIG. 276.—*Margaronia hyalinata*, larvæ, cocoon, and adults. (From the Author's Report for 1879.)

creature, with glistening white wings bordered with black, and with a spreading brush of long scales at the end of the abdomen.

Family PYRALIDIDÆ (Pyr-a-lid'i-dæ).

The Typical Pyralids (Pyr'a-lids).

The moths of this family are distinguished from other Pyralids, except the next family, by the absence of a fringe of hairs on the basal part of vein VII of the hind wings; and they are distinguished from that family by the fact that veins III_4 and III_5 of the fore wings are united at base (Fig. 277). It is one of the smaller of the families of Pyralids; fifty-four species are now enumerated in our lists.

The Meal-moth, *Pyralis farinalis* (Pyr′a-lis far-i-na′lis) is a common species. The larva feeds on meal, flour, and old clover-hay. The moth is commonly found near the food of the larva, but is often seen on the ceilings of rooms sitting with its tail curved over its back. It expands about an inch; the fore wings are light brown, crossed by two curved white lines, and with a dark chocolate-brown spot on the base and tip of each.

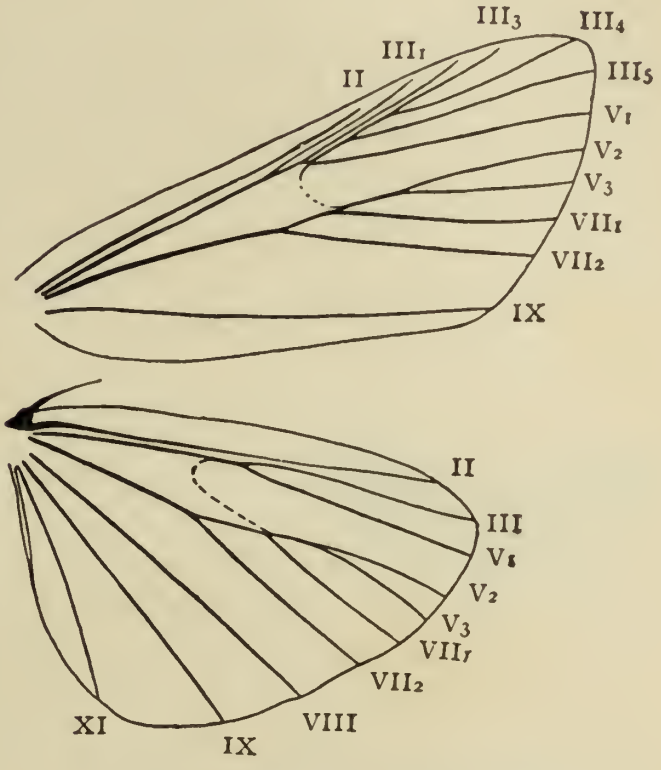


FIG. 277.—Wings of *Pyralis farinalis.*

The Clover-hay Worm, *Pyralis costalis* (Pyr′a-lis cos-ta′-lis). The larva of this species sometimes abounds in old stacks of clover-hay, and especially near the bottom of such stacks. As the infested hay becomes covered with a silken web spun by the larva, and by its black gunpowder-like excrement, much more is spoiled than is eaten by the insect. The moth expands about four fifths of an inch. It is of a beautiful lilac color, with golden bands and fringes (Fig. 278).

FIG. 278.—*Pyralis costalis.*

Family GALLERIIDÆ (Gal-le-ri′i-dæ).

The Bee-moth Family.

This is a small family, of which only seven species have been found in our fauna. The best known of these is the Bee-moth, *Galleria mellonella* (Gal-le′ri-a mel-lo-nel′la). The

larva of this species is a well-known pest in apiaries. It feeds upon wax; and makes silk-lined galleries in the honeycomb, thus destroying it. When full grown the larva is about an inch in length. It lies hidden in its gallery during the day, and feeds only at night, when the tired-out bees are sleeping the sleep of the just. When ready to pupate the caterpillar spins a tough cocoon against the side of the hive.

The moth has purplish-brown front wings, and brown or faded yellow hind wings. The fore wings of the male are deeply notched at the end, while those of the female (Fig. 279) are but slightly so. The female moth creeps into the hive at night to lay her eggs.

FIG. 279.—*Galleria mellonella.*

This pest is found most often in weak colonies of bees, which it frequently destroys. The best preventive of its injuries is to keep the colonies of bees strong. Of course the moths and larvæ should be destroyed whenever found. But the moths are slippery like other expert thieves, and run so rapidly when disturbed that it is very difficult to catch them.

FIG. 280.—*Crambus.*

Family CRAMBIDÆ (Cram'bi-dæ).

The Close-wings.

Although this is not a large family, there being only seventy-five species known in our fauna, the members of it are more often seen than any other Pyralids. The larvæ of most of the species feed on grass; and the adults fly up before us whenever we walk through meadows or pastures. When at rest, the moths wrap their wings closely about the body; this has suggested the name Close-wings for the insects of this family. When one of these moths alights on a stalk of grass it quickly places its body

parallel with the stalk, which renders it less conspicuous (Fig. 280). Many of the species are silvery white or are marked with stripes of that color.

More than fifty of our species belong to the genus *Crambus* (Cram'bus). The moths of this genus are often seen; but the larvæ usually escape observation. They occur chiefly near the surface of the ground, where they live in tubular nests constructed of bits of earth or vegetable matter.

Family PHYCITIDÆ (Phy-cit'i-dæ).

The Phycitids (*Phyc'i-tids*).

Our most common members of this family are small moths with rather narrow but long fore wings, which are banded or mottled with various shades of gray or brown. The family is, however, a large one and other types of coloration occur. The distinctive characteristics are those given in the table above. Figure 281 represents the venation of the wings.

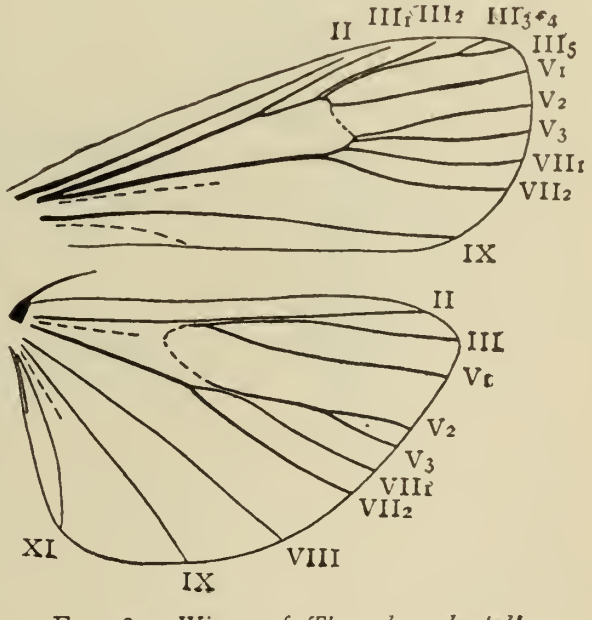


FIG. 281.—Wings of *Tlascala reductella.*

The larvæ of the different species vary greatly in habits. Some live in flowers, some fold or roll leaves within which they live and feed; some are borers; others feed upon dried fruits, or flour and meal; and one, at least, is predaceous, feeding on coccids. Usually the larva lives in a silken tube or case, lying concealed by day and feeding by night.

The case made by certain of the leaf-eating species is very characteristic in form (Fig. 282), being strongly tapering and much curved; in this instance the case is composed largely of the excrement of the larva.

FIG. 282.

The Indian-meal Moth, *Plodia interpunctella* (Plo'di-a in-ter-punc-tel'la) is the best known of the species that infest stored provisions. The larva is the small whitish worm, with a brownish-yellow head, that spins thin silken tubes through meal or among yeast-cakes, or in bags or boxes of dried fruits. The moth expands about five eighths of an inch. The basal two fifths of the fore wing is dull white or cream-colored; the outer part reddish brown, with irregular bands of blackish scales.

The Mediterranean Flour-moth, *Ephestia kühniella* (E-phes'ti-a kühn-i-el'la), is an even more serious pest than the preceding species, which it resembles in habits. It has become very troublesome in recent years in flouring-mills. The moth expands about one inch, and is grayish in color. Although it is called the Mediterranean Flour-moth, its source is not definitely known. Nor do we know of any easy way of ridding an infested mill of it. Carbon bisulphide is perhaps the most available insecticide in this case.

Zimmermann's Pine-pest, *Pinipestis zimmermanni* (Pin-i-pes'tis zim-mer-man'ni), is a common species, the larva of which is a borer. It infests the trunks of pine, causing large masses of gum to exude. The moths appear in midsummer.

The Coccid-eating Pyralid, *Lætilia coccidivora* (Læ-til'i-a coc-ci-div'o-ra), differs from the other members of this family in being predaceous. It feeds on the eggs and young of various scale-insects (*Pulvinaria*, *Dactylopius*, and *Lecanium*). Figure 283 represents the different stages of this insect enlarged, and the moths natural size resting on

egg-sacs of *Pulvinaria*. Like other members of this family the larva spins a silken tube, within which it lives. On a

FIG. 283.—*Lætilia coccidivora*; *a*, egg; *b*, larva; *c*, pupa; *d*, adult; *e*, *e*, moths natural size resting on egg-sacs of *Pulvinaria*.

thickly-infested branch these tubes may be found extending from the remains of one coccid to another.

Family Pterophoridæ (Pter-o-phor'i-dæ).

The Plume-moths.

The Plume-moths are so called on account of the remarkable form of the wings, which are split by longitu-

dinal fissures into more or less plume-like divisions. In most species the fore wing is separated into two parts, by a fissure extending about one half the length of the wing; while the hind wing is divided into three parts by fissures extending farther towards the base of the wing. Sixty species belonging to the family have been found in North America.

One of our most common species is the Gartered Plume, *Oxyptilus periscelidactylus* (Ox-yp'ti-lus per-is-cel-i-dac'ty-lus).

FIG. 284.—*Oxyptilus periscelidactylus.*

This is a small moth, expanding about seven tenths of an inch. It is of a yellowish brown color marked with dull whitish streaks and spots (Fig. 284). The larvæ hatch early in the spring, and feed upon the newly-expanded leaves of grape. They fasten together several of them, usually those at the end of a shoot, with fine white silk; between the leaves thus folded the caterpillars live either singly or two or three together. They become full grown and change to pupæ early in June. The pupa is not enclosed in a cocoon, but is fastened to the lower side of a leaf by its tail by means of a few silken threads, in nearly the same way that the chrysalids of certain butterflies are suspended. The pupa state lasts about eight days.

Family ORNEODIDÆ (Or-ne-od'i-dæ).

The Many-plume Moths.

FIG. 285.—*Orneodes hexadactyla.*

These insects resemble the Plume Moths in having the wings fissured; but here the fissuring is carried to a much greater extent than in that family, each wing being divided into six plumes (Fig. 285).

As yet only a single species of this family has been found in North America. This is *Orneodes hexadactyla* (Orne-o'des hex-a-dac'ty-la).

Superfamily TORTRICINA (Tor-tri-ci'na).

The Tortricids (*Tor'tri-cids*).

The Tortricids are generally small moths; but as a rule they are larger than the Tineids. They have broad front wings, which usually end squarely. The costa of the front wing curves forward strongly near the base of the wing. When at rest the broad front wings fold above the body like a roof. The moths are variegated in color, but are usually brown, gray, or golden rather than of brighter hues. As a rule the hind wings are of the color of the body and without markings. In the venation of the wings they differ from the Pyralids in having subcosta and radius of the hind wings widely separate beyond the end of the discal cell; and from the Tineids in having the second anal vein of the hind wings forked towards the base (Fig. 286).

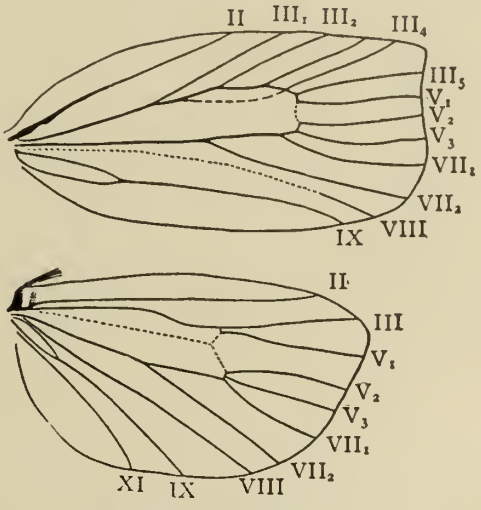


FIG. 286.—Wings of *Cacœcia cerasivorana*.

FIG. 287. — Leaf rolled by a larva, probably a Tortricid.

The larvæ vary greatly in habits; but a large proportion of them are leaf-rollers (Fig. 287). It was this habit that suggested the name *Tortrix* (Tor'trix) for the typical genus, from which the names of one family and of the superfamily are derived. A large proportion of the rolled leaves found upon shrubs and trees are homes of Tortricid larvæ. But it should be remembered that the leaf-rolling habit is not confined to this family.

The rolled leaves serve the Tortricid larvæ not merely as homes but also as food, for they feed upon the enclosed portions. Sometimes several leaves are used by a larva, but more often only one, or in many cases merely a tip or one edge of a leaf is used. Some species cut a slit in a leaf and roll only one part of it. They also differ greatly as to the extent to which the leaves are rolled. Some species are gregarious, an entire brood making a common nest. During the latter part of the summer and in the autumn these rolled leaves can be found on almost any tree or shrub.

In nearly all cases entomologists in naming Tortricids have formed the specific name with the ending *-ana*; so that the form of the name indicates the family to which the insect belongs.

More than four hundred North American species of Tortricids are known. The superfamily includes three families, which can be separated by the following table:—

A. With a fringe of long hairs on the basal part of vein VII of the hind wings, on the upper side of the wing. Do not mistake a bunch of long hairs arising from the wing back of vein VII for this fringe. p. 240.....GRAPHOLITHIDÆ.

AA. Without a fringe of long hairs on the basal part of vein VII of the hind wings.

B. Vein VII_2 of the fore wings arising from the outer fourth of the discal cell, p. 243.....CONCHYLIDÆ.

BB. Vein VII_2 of the fore wings arising from a point before the outer third of the discal cell, p. 244.....TORTRICIDÆ.

Family GRAPHOLITHIDÆ (Graph-o-lith'i-dæ).

The Grapholithids (*Gra-phol'i-thids*).

These moths are easily distinguished from other Tortricids by the presence of a fringe of long hairs on the basal part of cubitus of the hind wing. To this family belong nearly two thirds of our species of Tortricids. The following are some of our more common species:—

The Codlin-moth, *Carpocapsa pomonella* (Car-po-cap'sa pom-o-nel'la).—This is the best-known and probably the most important insect enemy of the fruit-grower. The larva is the worm found feeding near the core of wormy apples. The adult (Fig. 288) is a beautiful little creature with finely mottled pale gray or rosy fore wings. There is a large brownish spot near the end of the fore wing, and upon this spot irregular, golden bands. The moth issues from the pupa state in late spring and lays its eggs singly in the maturing blossoms of the apple just as the petals fall. As soon as the larva hatches it burrows into the apple and eats its way to the core, usually causing the fruit to fall prematurely. When full grown the larva burrows out through the side of the fruit, and undergoes its transformations within a cocoon, under the rough bark of the tree, or in some other protected place. The species is both single-brooded and double-brooded. The larvæ winter in their cocoons, transforming to pupæ during early spring.

FIG. 288.—*Carpocapsa pomonella.*

The method of combating this pest that is most commonly employed now is to spray the trees with Paris-green water, just after the petals fall and before the young apples are heavy enough to droop. The falling spray lodges in the blossom end of the young apple, and the larva which hatches from an egg laid in this position gets a dose of poison with its first meal, and dies before it can eat its way into the apple.

The Bud-moth, *Tmetocera ocellana* (Tme-toc'e-ra oc-el-la'na).—The larva of this insect is also a pest infesting apple-trees. It works in opening fruit-buds and leaf-buds, often eating into them, especially the terminal ones, so that all new growth is stopped. It also ties the young leaves at the end of a shoot together and lives within the cluster thus formed, adding other leaves when more food is needed. Sometimes so large a proportion of the fruit-buds are destroyed as to

seriously reduce the amount of the crop. The pupa state is passed within the cluster of tied leaves or within a tube formed by rolling up one side of a leaf, and lasts about ten days. The moth expands about three fifths of an inch; it is of a dark ashen gray, with a large, irregular, whitish band on the fore wing.

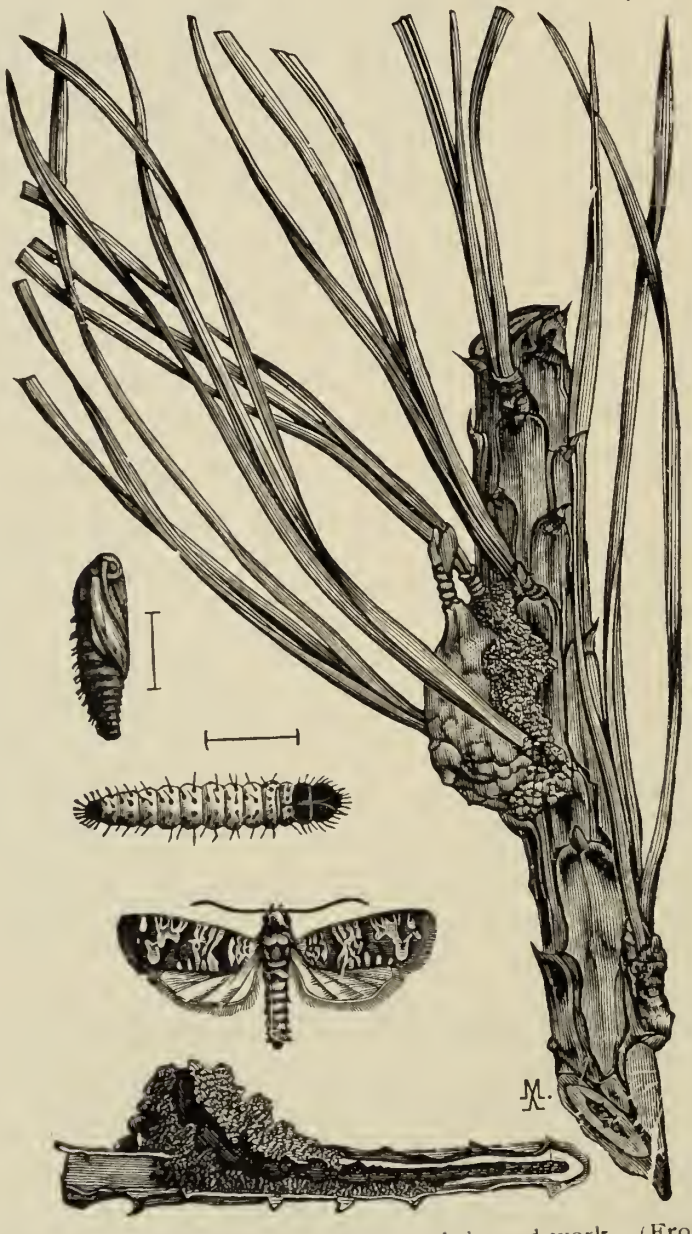


FIG. 289.—*Retinia comstockiana*, larva, pupa, adult, and work. (From the Author's Report for 1879.)

The Pitch-pine Retinia, *Retinia comstockiana* (Re-tin'i-a com-stock-i-a'na).—This species (Fig. 289) illustrates well

the habits of the boring species. The larva infests the small branches of pitch-pine. It is a yellowish-brown caterpillar, which makes a burrow along the centre of the branch. Its presence may be detected by the resin that flows out of the wound in the twig and hardens into a lump. Two of these lumps are shown in the figure, one of them splits lengthwise, and the other with a pupa-skin projecting from it. The larva, pupa, and adult are also figured. The moth is represented natural size; the darker shades are dark rust-color, and the lighter, light-gray. The insect winters as a larva; the adult emerges in May and June.

FIG. 290.—*Retinia frustrana*. larva, pupa, adult, and work. (From the Author's Report for 1879.)

The Frustrating Retinia, *Retinia frustrana* (frus-tra'na).—This species infests the new growth of several species of pine, spinning a delicate web around the terminal bud, and mining both the twig and the bases of the leaves. The larva, pupa, and adult are represented somewhat enlarged in the figure. An infested twig is also shown (Fig. 290).

Family CONCHYLIDÆ (Con-chyl'i-dæ).

The Conchylids (*Con'chy-lids*).

This is the smallest of the three families of Tortricids, less than fifty species occurring in our fauna. The members of it can be recognized by the characters given in the table above. Comparatively little is known about the habits of our species.

The Juniper Web-worm, *Conchylis rutilana* (Con'chy-lis ru-ti-la'na), is an imported species which has attracted atten-

tion by its injuries to junipers, the leaves of which it fastens together with silk. In this way it makes a more or less perfect tube within which it lives. The moth expands about one half inch, and has bright, glossy, orange, fore wings, crossed by four reddish brown bands.

Family TORTRICIDÆ (Tor-tric'i-dæ).

The Typical Tortricids (*Tor'tri-cids*).

The Tortricidæ agree with the preceding family in lacking a fringe of long hairs on the basal part of vein VII of the hind wings, but differ in that vein VII_2 of the hind wings separates from the main stem before the outer third of the discal cell. More than one hundred and twenty North American species are known.

Several of our best-known members of this family belong to the genus *Cacœcia* (Ca-cœ'ci-a). These may be called the Ugly-nest Tortricids, ugly dwelling being the meaning of *Cacœcia*, and also descriptive of the nests of the larvæ of these insects.

Figure 291 represents the nest of the larva of *Cacœcia rosana* (C. ro-sa'na), which we bred on currant; and Figure 292, the adult of this species. This moth expands three fourths of an inch. The fore wings are olive-brown, crossed by bands of darker color; the hind wings are dusky. This species differs from the two following in that each larva makes a nest for itself.

FIG. 291.—Nest of *Cacœcia rosana*.

FIG. 292.—*Cacœcia rosana*.

The Cherry-tree Ugly-nest Tortricid, *Cacœcia cerasivorana* (C. cer-a-si-vo-ra'na), lives upon the choke-cherry and sometimes upon the cultivated cherry. The larvæ, which are yellow, active creatures, fasten together all the leaves and twigs of a branch and feed upon them (Fig. 293), an entire brood occupying a single nest. The larvæ change to pupæ within the nest; and the pupæ, when about to transform, work their way out and hang suspended from the outer portion of the nest, clinging to it only by hooks at the tail end of the body. Here they transform, leaving the empty pupa-skins projecting from the nest, as shown in the figure. The moths vary in size, the wing expanse of those we have bred ranging from four fifths of an inch to nearly one and one-fifth inches. The wings are bright ochre-yellow; the front pair marked with irregular brownish spots and numerous transverse bands of pale leaden blue (Fig. 294 male, 295 female).

FIG. 293.—Nest of *Cacœcia cerasivorana.*

FIG. 294.—*Cacœcia cerasivorana*, male.

FIG. 295.—*Cacœcia cerasivorana*, female.

The Oak Ugly-nest Tortricid, *Cacœcia fervadana* (C. ferva-da'na).—The nests of this species are common on our oak-trees in late summer. They are merely a wad of leaves fastened together. Each nest contains several larvæ; later the empty pupa-skins may be found clinging to the outside of the nest as in the preceding species.

The Pine-leaf Tube-builder, *Lophoderus politana* (Lo-

phod'e-rus pol-i-ta'na).—One of the most interesting of Tortricid nests occurs commonly on white pine. Each nest consists of from six to ten leaves drawn together so as to form a tube, and is lined within with silk. This tube serves as a protection to the larva, from which it comes out to feed upon the ends of the very leaves of which the tube is composed; in this way the tube is shortened. We bred the moth from nests collected at Ithaca, New York; but we have found similar nests as far south as Florida. The moth expands one half inch. Its head, thorax, and fore wings are of a dull rust-red color, with two oblique paler bands crossing the fore wings, one a little before the middle, the other beyond, parallel to it.

Superfamily TINEINA (Tin-e-i'na).

The Tineids (*Tin'e-ids*).

The Tineids are nearly all minute moths with narrow wings, which are bordered with wide fringes. A few species are of considerable size, and have broader wings, with narrower fringes.

The narrow-winged forms can be distinguished from all other moths by the shape of the wings and the great width of the fringes. The moths figured below (Figs. 298, 299, 300, 302) illustrate this. It should be remembered that in each of these figures the insect is represented greatly enlarged; in most cases the size of the insect is represented by a hair-line near the figure.

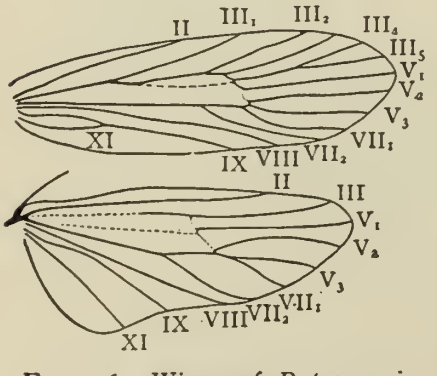


FIG. 296.—Wings of *Depressaria heracliana*.

The wide-winged forms are most surely distinguished by the venation of the wings. In its more general features the venation of the wings in this family is similar to that of the Tortricids; it differs, how-

ever, in that the second anal vein of the *hind* wings is not forked towards the base (Fig. 296).

The venation of the wings of the more generalized Tineids is quite primitive in type; there are two anal veins in the fore wings, three anal veins in the hind wings, and the base of vein V is preserved throughout the length of the discal cell. But the more specialized members of the superfamily present a wide departure from this generalized type. With these the base of vein V has disappeared from both pairs of wings, and the venation of the hind wings is reduced to a greater extent than is seen elsewhere in winged Lepidoptera.

Correlated with this great reduction of the hind wings there has been a great expansion of the fringe of the wing. It is evident that the fringe of the wing takes the place of the wing-membrane as an organ of flight. In those Tineids that we have studied carefully the hairs composing the fringe are inserted in the lower side of the wing-membrane a short distance back from the edge of the wing; and the edge of the wing is stiffened above by strong overlapping scales. This arrangement renders the fringe rigid during the downward stroke of the wing, but admits of its depression during the upward stroke; a combination well adapted to facilitate flight. The substitution of wide fringes for the wing-membrane occurs in some other minute insects, as Thrips and certain minute, parasitic Hymenoptera.

To this superfamily belong the smallest of the Lepidoptera; many of them are so minute that the larvæ live until full grown within the tissue of leaves.

These tiny moths are often very beautiful, their wings being marked with scales that shine like silver or gold; but they are so small that it is necessary to examine them with a lens to appreciate their beauty.

The larvæ of nearly all Tineids feed upon vegetable matter. The majority of them feed upon or within the leaves of plants, but many live within nuts, or seeds, or dried fruits; a few feed upon dead animal matter, as woolens, furs, and feathers; and some are predaceous, destroying scale-bugs.

Entomologists have a custom of terminating the name of each species of Tineid with *-ella*. Thus we have *Tinea*

granella, *Adela ridingsella*, *Bucculatrix pomonella*, and many hundreds of others; until the syllable *-ella* always brings before us a vision of a tiny moth, with narrow wings bearing long delicate fringes.

The Tineids are very numerous, there being nearly one thousand described American species; and doubtless there are many undescribed as yet. The superfamily is composed of several families; but, as the study of these insects is too difficult to be carried far by the beginning student, we will not take the space to define these families in this work. We will merely describe the habits of a few species.

At first thought the leaves of our common shrubs and trees seem quite as thin as if they had been cut out of sheets of paper. But the reader has doubtless learned in the study of Botany that the upper and the lower surfaces of a leaf are each covered with a thin skin or epidermis, and that between these two skins there is a fleshy portion called the parenchyma. But if botanists had failed to teach us this lesson, the Tineid larvæ would have done so; for many of these little creatures live until full grown between the two skins of a leaf, and derive their nourishment from the parenchyma. As our coal-miners dig tunnels in the earth, so do these larvæ eat out long passages in the substance of a leaf, without breaking through either epidermis.

During the late summer and autumn there can be found on almost any shrub or tree leaves that are more or less discolored by white or grayish blotches or by long twisted lines that reveal the abiding-places of leaf-miners. Surely Mr. Lowell must have had these in mind when he wrote:

> "And there's never a leaf nor a blade too mean
> To be some happy creature's palace."

Not only are very many kinds of plants infested by Tineid larvæ, but the mines in the leaves differ greatly in form and in their position in the leaf. These differences in food-plant and in the shape and position of the mines do

not indicate that these larvæ are inconstant in their habits. In fact, the opposite is the case. Each species of Tineid infests a particular species of plant, or, at the most, several closely allied plants. And each species makes a mine of definite shape, although some species exhibit different habits in the different stages of their growth. So constant are these creatures in their habits that in most cases an expert can determine the species of Tineid that made a mine by merely examining the infested leaf.

The various kinds of mines can be classed under a few distinct types. The long, narrow, and more or less winding mines are described as *linear mines.* Some of these are very narrow at their beginning and gradually enlarge, resembling in outline a serpent; frequently the larger end is terminated by a blotch-like enlargement, suggesting a head. Such mines are termed *serpentine mines.* The leaves of the wild columbine are often marked by serpentine mines (Fig. 297). Other mines that start from a narrow beginning enlarge more rapidly and extend in a more or less regular curve; these are *trumpet mines.* A common example of a trumpet mine is that made by the larva of *Tischeria malifoliella* (Tis-che'ri-a mal-i-fol-i-el'la) in the leaves of apple. The mines of many species are mere disk-like blotches; these are referred to as *blotch mines* (Fig. 298). Blotch mines differ in position; some are immediately beneath the upper epidermis, while others are nearer the lower surface of the leaf. This distinction exists also in most of the other types of

FIG. 297.—Leaf with serpentine mines.

mines. In some of the blotch mines the epidermis of one side of the leaf is thrown into a fold by the growth of the leaf; these are *tentiform mines.*

In addition to peculiarities in shape many mines are marked by characteristic lines or spots composed of the droppings of the larva.

The following species will serve to illustrate the habits of these remarkable insects.

The White-blotch Oak-leaf Miner, *Lithocolletis hamadryadella* (Lith-o-col-le'tis ha-mad-ry-a-del'la).—This little miner infests the leaves of many different species of oak, and some-

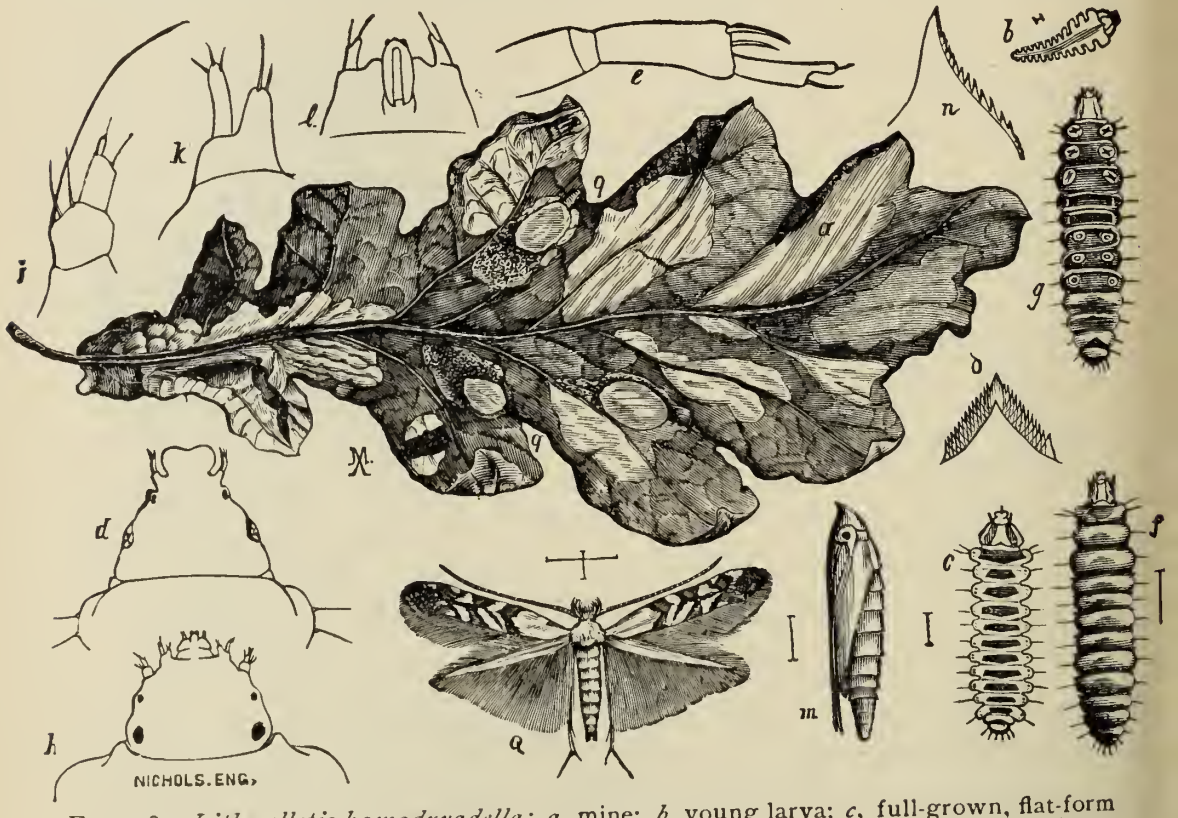


FIG. 298.—*Lithocolletis hamadryadella: a*, mine; *b*, young larva; *c*, full-grown, flat-form larva; *d*, head of same, enlarged; *e*, antenna of same, enlarged; *f*, round-form larva from above; *g*, same from below; *h*, head of same, enlarged; *i*, antenna of same, enlarged; *k*, maxilla and palpus of same, enlarged; *l*, labium, labial palpi, and spinnerets of same; *m*, pupa; *n*, side view of pupal crest; *o*, front view of same; *q*, cocoon; *Q*, moth. (From the Author's Report for 1879.)

times it is extremely abundant. We have seen trees infested so badly that there were on an average four or five mines in each leaf. Figure 298 represents a leaf from such a tree. The mine is a whitish, blotch mine in the upper side of the leaf.

The young larva is remarkable in resembling more the larva of a beetle than the ordinary type of lepidopterous larvæ. It is nearly flat; the first thoracic segment is much larger than any of the others; the body tapers towards the hind end; and there are only the faintest rudiments of legs discernible. The larvæ molt seven times. At the seventh molt the form of the body undergoes a striking change. It now becomes cylindrical in form, there is a great change in the shape of the mouth-parts, and the fourteen feet are well developed. This change in form during the life of the larva is characteristic of a large group of Tineids of which this species may be taken as a type. The full-grown cylindrical larva measures about one fifth inch in length. It spins a cocoon, which is simply a delicate, semi-transparent, circular sheet of white silk, stretched over a part of the floor of the mine. The pupa is dark brown in color, and bears a toothed crest upon its head, which enables it doubtless to pierce or saw its way out from the cocoon. The moth is a delicate little creature, whose wings expand a little more than one fourth inch. The fore wings are white, with three, broad, irregular, bronze bands across each, and each band is bordered with black on the inner side. The hind wings are silvery.

As this insect passes the winter as a larva within the dry leaves, the best way to check its ravages when it becomes a pest is to rake up and burn such leaves.

The Palmetto-leaf Miner, *Laverna sabalella* (La-ver'na sab-a-lel'la).—This species occurs only in the South where the saw-palmetto grows. But it is of general interest as illustrating a peculiar type of larval habit. The larvæ can hardly be said to be leaf-miners; for they feed upon the upper surface of the leaf, destroying the skin as well as the fleshy part of the leaf. They are social, working together in small companies, and make a nest consisting of a delicate sheet of silk covering that part of the leaf upon which they are feeding; this sheet is covered with what appears like sawdust, but which is really a mass of the droppings of the

larvæ (Fig. 299). The full grown larva attains a length of half an inch. The pupa state is passed within the nest made by the larvæ. The moth is quite large for a Tineid, the wings expanding five eighths of an inch. Its general color is

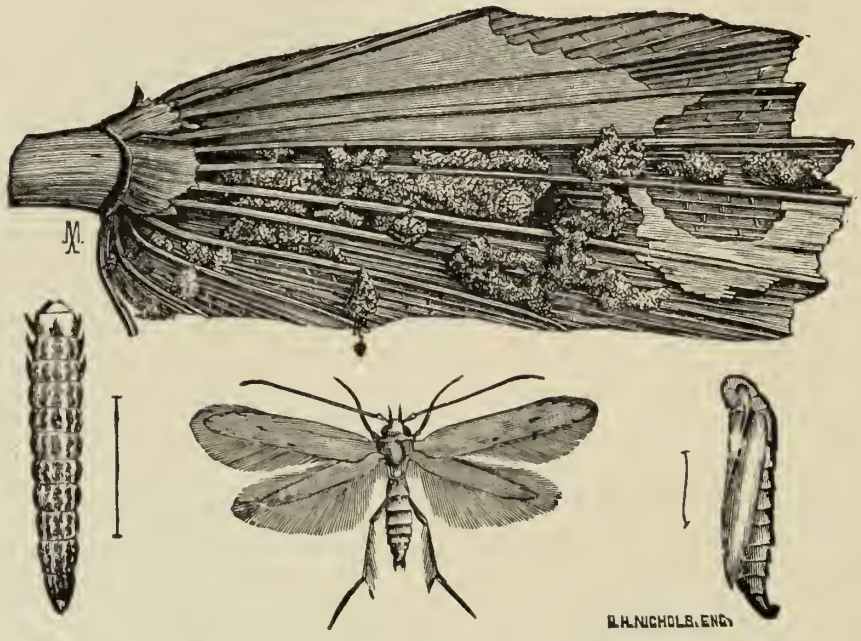


FIG. 299.—*Laverna subalella*, larva, pupa, adult, and part of injured leaf. (From the Author's Report for 1879.)

a delicate silvery gray, with a tinge of lavender in some individuals.

The Pine-leaf Miner, *Gelechia pinifoliella* (Ge-le'chi-a pin-i-fol-i-el'la).—It often happens that the ends of the leaves of pine present a dead and brown appearance that is due to the interior of the leaf having been eaten out. This is the work of the Pine-leaf Miner (Fig. 300). At the right season it is easy to see the long, slender larva in its snug retreat by holding a leaf up to the light and looking through it; and later the pupa can be seen in the same way. Near the lower end of the tunnel in each leaf there is a round hole through which the larva entered the leaf and from which the adult emerges. We have found this insect in several of the stouter-leaved species of pine, but never in the slender leaves of the white pine. In the North it is most abundant in the leaves of pitch-pine.

The Apple Bucculatrix, *Bucculatrix pomifoliella* (Buc-cu-la'trix pom-i-fol-i-el'la).—This insect differs in habits in sev-

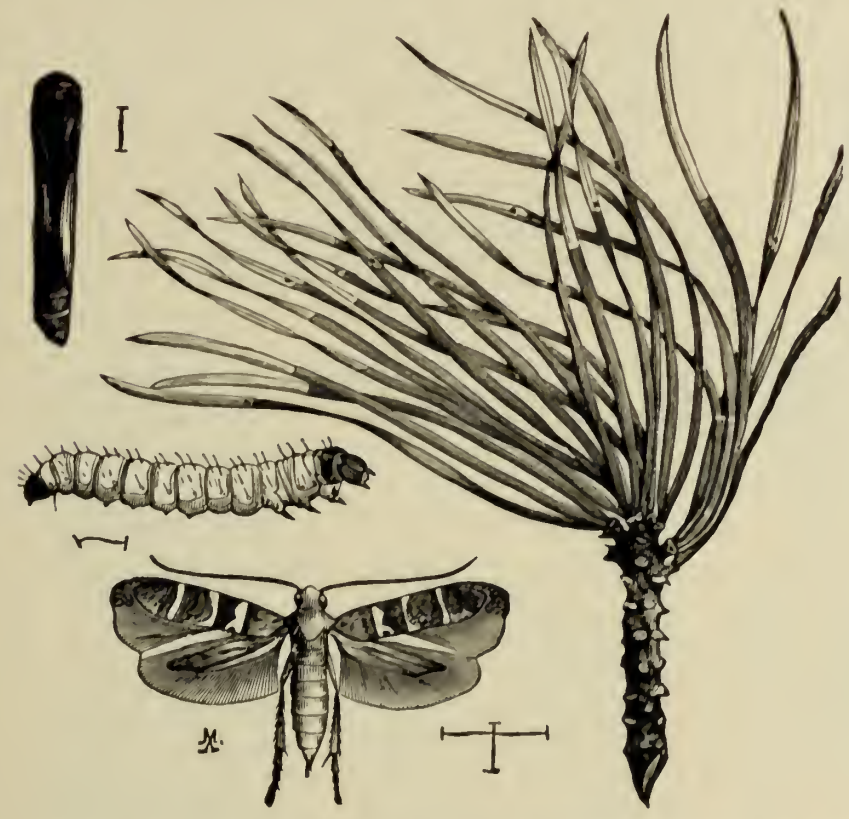


FIG. 300.—*Gelechia pinifoliella*, larva, pupa, adult, and leaves mined by the larva. (From the Author's Report for 1879.)

eral respects from any of the other Tineids described here. The larva infests the leaves of apple, and when full grown it makes a small white cocoon which is attached to the lower surface of a twig. These cocoons sometimes occur in great numbers, side by side, on the twigs of an infested tree (Fig. 301). They are easily recognized by their shape being slender, and ribbed lengthwise. It is these cocoons that usually first reveal the presence of this pest in an orchard. They are very conspicuous during the winter when the leaves are off the trees. At this time each cocoon contains a pupa. The adult moth emerges in early spring. The eggs are laid on the lower surface of the leaves. Each larva when it hatches bores directly from the egg to the upper surface of the leaf, where it makes a brown serpentine

mine. When these mines are abundant in a leaf it turns yellow and dies. When the larva has made a mine from one half to three fourths of an inch long, which it does in from four to five days, it eats its way out through the upper surface. Then somewhere on the upper surface of the leaf it weaves a circular silken covering about one-twelfth inch in diameter. Stretched out on this network the larva, which is now about one-tenth inch long, makes a small hole in it near its edge, then, as one would turn a somersault, it puts its head into this hole and disappears beneath the silken covering, where it undergoes a change of skin. It remains in the *molting cocoon* usually less than twenty-four hours. After leaving this cocoon it feeds upon the leaves without making a mine; and in a few days makes a second molting cocoon which differs from the first only in being about one-eighth inch in diameter. After leaving this it again feeds for a few days, and then migrates to a twig where it makes the long ribbed cocoon within which the pupa state is passed. This very interesting life-history was first worked out by Mr. A. E. Brunn while a student in the writer's laboratory at Cornell University.

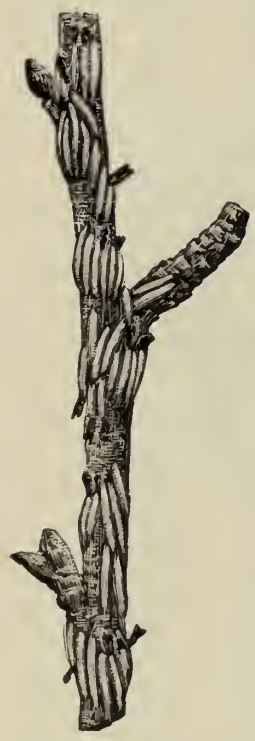


FIG. 301. — Cocoons of *Bucculatrix pomifoliella*.

When it is necessary to combat this pest the smaller twigs bearing cocoons should be pruned as far as practicable during the winter and burned, and those cocoons that remain on the larger branches should be washed with strong kerosene emulsion.

The Resplendent Shield-bearer, *Aspidisca splendoriferella* (As-pi-dis'ca splen-do-rif-e-rel'la).—This Tineid is both a miner and a case-bearer. It feeds within apple-leaves, and at first makes a linear mine; but later this is enlarged into a blotch mine. When full grown the larva makes an oval case

cut from the walls of its mine and lined with silk. It then seeks a safe place in which to fasten this case and pass the winter. This is usually on the trunk or on a branch of the infested tree (Fig. 302). Once some of these migrating larvæ dropped from a tree upon the writer's hat and carefully

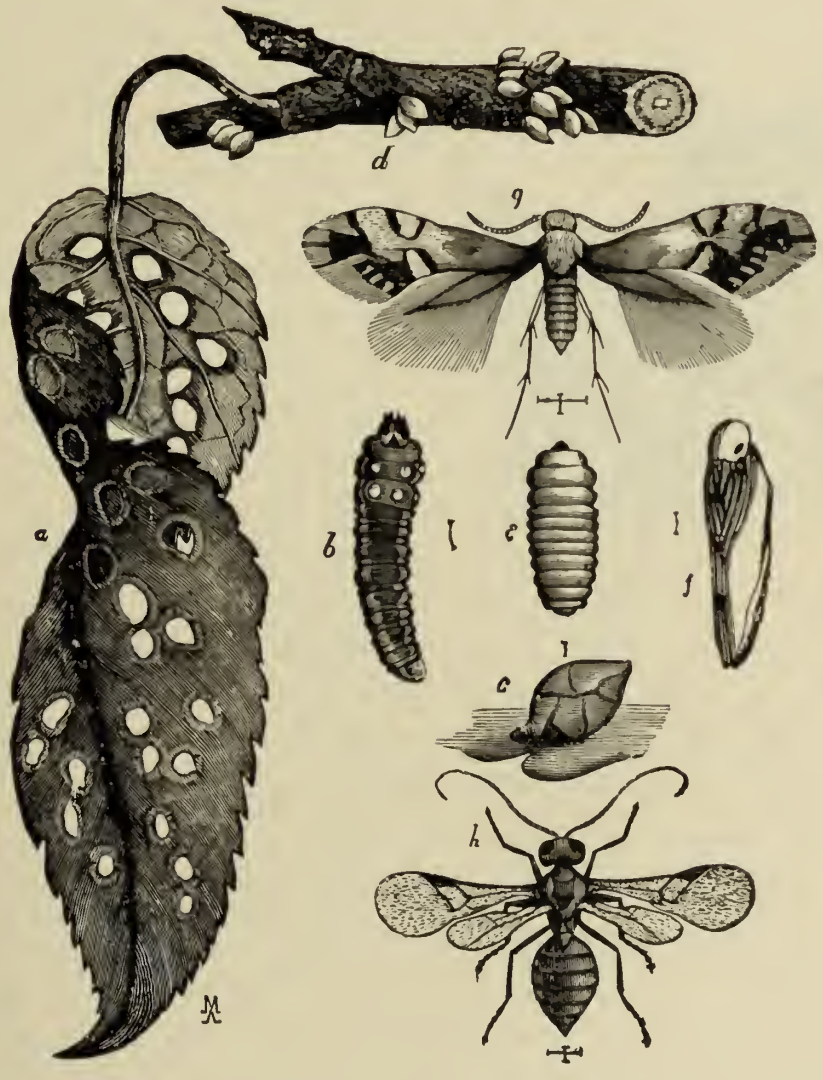


FIG. 302.—*Aspidisca splendoriferella* : *a*, leaf of apple showing work; *b*, summer larva; *c*, larva in case travelling; *d*, cases tied up for winter; *e*, hibernating larva; *f*, pupa; *g*, moth; *h*, parasite. (From the Author's Report for 1879.)

fastened themselves to the band with misplaced confidence that they could remain there till spring. The adult has gray and golden wings with silvery and dark markings.

The Maple-leaf Cutter, *Incurvaria acerifoliella* (In-cur-va′ri-a a-cer-i-fol-i-el′la).—This insect illustrates still another

curious type of larval habits. It infests the leaves of maple, and occasionally is so abundant that it does serious injury. The leaves of an infested tree present a strange appearance (Fig. 303). They are perforated with numerous elliptical holes, and marked by many more or less perfect ring-like patches in which the green substance of the leaf has been destroyed, but each of which incloses an uninjured spot. These injuries are produced as follows: The young larva cuts an oval piece out of a leaf, places it over its back, and fastens it down with silk around the edges. This serves as a house beneath which it lives. As it grows this house becomes too small for it. It then cuts out a larger piece which it fastens to the outer edges of the smaller one, the larva being between the two. Then it fastens one edge of this case to the leaf by a silken hinge so that it will not fall to the ground "cradle and all," and then turns the case over so that the larger piece is over its back. When it wishes to change its location it thrusts out its head and fore legs from the case and walks off, looking like a tiny turtle. When it wishes to eat it fastens the case to the leaf and, thrusting its head out, eats the fleshy part of the leaf as far as it can reach. This explains the circular form of the patches, the round spot in the center indicating the position of the case. The insect passes the winter in the pupa state within its case, which falls to the ground with the infested leaf. The moth is of a brilliant steel-blue or bluish-green color without spots; it appears in early summer.

FIG. 303.—Leaf infested by *Incurvaria*.

Other Case-bearers.—The two case-bearers described above make their cases out of fragments of leaves; there are others that use the husks of seeds which they have eaten. Such cases are extremely protective, appearing to be merely seeds. But there are some Tineid case-bearers that make their cases entirely of silk. These are usually more or less nearly cylindrical, and are carried projecting out at a considerable angle from the object upon which the insect walks. When the insect is at rest and when it is undergoing its transformations the mouth of the case is closely fastened to some object, so that the insect is completely concealed. Considerable differences exist in the form of these silken cases. In a quite common type the case is nearly cylindrical, with a flaring lip at the head end, and with the hind end three-sided, as if it had been pinched between one's thumb and two fingers. In another type the hind end of the case is somewhat enlarged and curved downward so that the case is shaped like a pistol.

The Clothes-moths.—These are the dread of every housekeeper. The mere mention of the word "moths" is enough to conjure up visions of household treasures of woolen and fur eaten full of holes, their beauty gone, their usefulness past. It was formerly supposed that these well-known injuries were caused by a single species; but it has since been discovered that we have in this country three species of clothes-moths. These differ in habits as well as in structure.

The Case-bearing Clothes-moth, *Tinea pellionella* (Tin'e-a pel-li-o-nel'la).—The larva of this species is a true case-bearer, making a case out of bits of its food-material which are fastened together with silk. As the larva grows it enlarges its case by adding to each end and by slitting it and inserting a piece. Instructive specimens can be obtained by rearing the larvæ, and changing them from time to time from flannel of one color to that of another. The shape of the successive additions to the case, being of different colors, can be easily seen. The pupa state is passed within the

case. The adult is a small brown moth with a few dark spots on its fore wings.

The Tube-building Clothes-moth, *Tinea tapetzella* (T. tap-et-zel'la).—The larva of this species makes a gallery composed of silk mixed with fragments of cloth. This gallery is long and winding and can be easily distinguished from the case of the preceding species. The pupa state is passed within the gallery. The moth differs greatly in appearance from the other two species, the fore wings being black from the base to the middle and white beyond.

The Naked Clothes-moth, *Tinea biselliella* (T. bi-sel-li-el'la).—Although this species spins some silk wherever it goes, it makes neither a case nor a gallery. It may be termed, therefore, the Naked Clothes-moth, in contradistinction to the other two species. But when the larva is full grown it makes a cocoon, which is composed of fragments of its food-material fastened together with silk. The adult is of a delicate straw-color, without dark spots on its wings.

Protection from Clothes-moths.—In late spring or early summer all winter clothing, flannels, furs, and other articles that are to be put away for the summer should be thoroughly brushed or examined for these pests, and exposed to the sunlight as long as practicable. Then they should be wrapped carefully in stout paper, or better packed in pasteboard boxes, which can be procured at small cost, and the crack between the cover and the box closed by pasting a strip of paper over it.

The Angoumois Grain-moth, *Gelechia cerealella* (Ge-le'chi-a ce-re-a-lel'la).—Although this insect is closely allied to the Pine-leaf Miner, its habits are very different. This insect feeds upon seeds, and especially upon stored grain. It occurs throughout our country; but it is especially destructive in the Southern States. In that part of the country it is extremely difficult to keep grain long on account of this pest and certain beetles that also feed on stored grain. The adult moth is of a very light grayish-brown

color, more or less spotted with black; it expands about half an inch. The common name is derived from the fact that it has been very destructive in the province of Angoumois, France.

Family SESIIDÆ (Se-si'i-dæ).

The Clear-winged Moths or Sesiids (Se'si-ids).

The Clear-winged Moths constitute a very remarkable family, many of them resembling bees or wasps in appearance more than they do ordinary moths, a resemblance due to their clear wings and in some cases to their bright colors (Fig. 304). There are a few moths in other families, as the Clear-winged Sphinxes, and certain Zygænids, that have a greater or less part of the wings devoid of scales; but they are exceptions. Here it is the rule that the greater part of one or both pairs of wings are free from scales; hence the common name Clear-winged Moths.

FIG. 304.

These insects are of moderate size; as a rule they have spindle-shaped antennæ, which are terminated by a small silky tuft; sometimes the antennæ are pectinate; the margins of the wings and the veins of even the clear-winged species are clothed with scales; and at the end of the abdomen there is a fan-like tuft of scales.

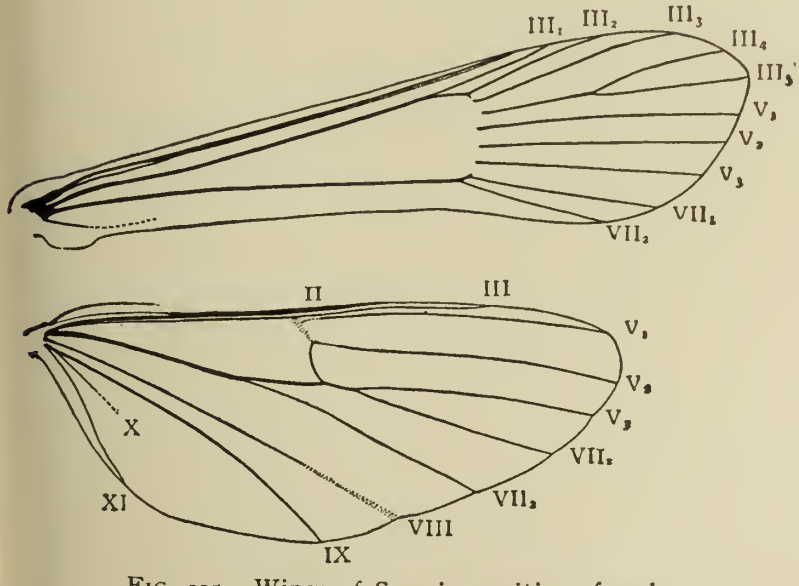


FIG. 305.—Wings of *Sannina exitiosa*, female.

The fore wings are remarkable for their extreme narrow-

ness and the great reduction of the anal area (Fig. 305); while the hind wings have a widely expanded anal area. There is great variation within the family in the number of anal veins in the hind wings, the number ranging from two to four. The maximum number of anal veins in the Lepidoptera has generally been considered to be three; but in certain forms belonging to this family a fourth (vein X) is quite well represented.

Another remarkable feature of all the forms that we have studied is that in the female the bristles composing the frenulum are consolidated as in the male. The females also possess a frenulum hook; but this is not so highly specialized as that of the male.

The adults fly very swiftly and during the hotter part of the day. They frequent flowers, thus increasing their resemblance to bees or wasps. The larvæ are borers, living within the more solid parts of plants. Some species cause serious injury to vegetation. Nearly one hundred and fifty species have been found in this country. Doubtless many more exist; for the family has not been thoroughly studied as yet. The following species have attracted much attention on account of their serious ravages.

The Peach-tree Borer, *Sannina exitiosa* (San-ni′na ex-it-i-o′sa).—This is the most important insect enemy of the peach-tree. In some parts of the country it is difficult to find a peach-tree that is not infested by it. The eggs are laid on the bark of the tree near the ground. The larvæ bore downward in the bark of the trunk just below the surface of the ground. Their burrows become filled by a gummy secretion of the tree. As this oozes out in large masses the presence of the borer is easily detected by it. When full grown the larva comes to the surface of the ground and makes a cocoon of borings fastened together with silk. The perfect insects appear from May till October, but most of them in the latter part of June and early in July. There is a single generation each year. The adults

differ greatly in appearance. The general color of both sexes is a glassy steel-blue. In the female (Fig. 306) the fore wings are covered with scales, and there is a bright orange-colored band on the abdomen. In the male both pairs of wings are nearly free from scales. No better method of fighting this pest has been found than to carefully watch the trees and remove the larvæ with a knife as soon as discovered.

FIG. 306.—*Sannina exitiosa.*

The Pacific Peach-tree Borer, *Sannina pacifica* (S. pacif'i ca).—On the Pacific Coast there is a peach-tree borer that is distinct from the above, and appears to be an even more serious pest. The larva is more difficult to remove from the tree, as it bores into the solid wood. The female of this species lacks the orange-colored band on the abdomen.

The Currant Borer, *Sesia tipuliformis* (Se'si-a tip-u-li-for'-mis).—This species is closely allied to the two preceding, but is smaller, expanding only about three fourths of an inch. There are but few scales on either pair of wings except on the tip and discal vein of the fore wings and the outer margin of the hind wings. The eggs are laid on the twigs of currant. The larvæ penetrate the stem, and devour the pith; in this way they make a burrow in which they live and undergo their transformations. The perfect insects appear in June. Before this time the leaves of the infested plant turn yellow. If such plants be cut and burned in May the pest will be destroyed.

The Pine Sesian, *Harmonia pini* (Har-mo'ni-a pi'ni).—Frequently there may be seen on the trunks of pine-trees large masses of resinous gum mingled with sawdust-like matter. These are the results of the work of the larvæ of this insect, which bore under the bark and into the superficial layers of the wood. The adult resembles the female of the Peach-tree Borer, but the abdomen is more extensively marked with orange.

The Squash-vine Borer, *Melittia ceto* (Me-lit'ti-a ce'to).—The larva of this species (Fig. 307) does great damage by eating the interior of squash-vines. In some places it is

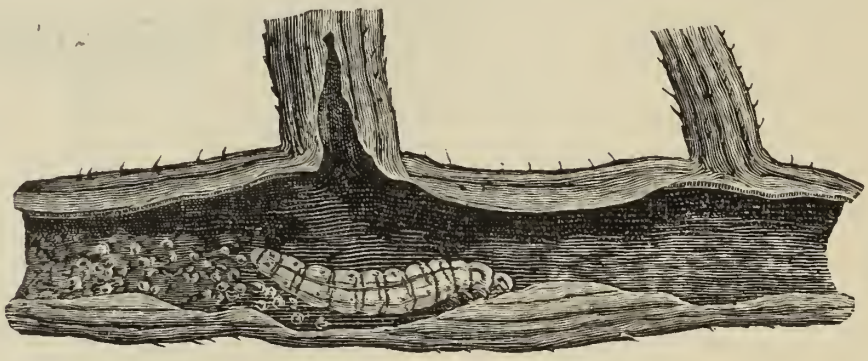


FIG. 307.—*Melittia ceto*, larva in squash-vine.

almost impossible to raise squashes on account of its ravages. The fore wings of the adult are covered with scales, and the hind legs are fringed with long orange-colored scales.

Family DIOPTIDÆ (Di-op'ti-dæ).

The Dioptids (*Di-op'tids*).

This family is represented in our fauna by a single known species, *Phryganidia californica* (Phryg-a-nid'i-a cal-i-for'-

FIG. 308.—*Phryganidia californica.*

ni-ca), which occurs in California. This is a pale-brown insect, with nearly transparent wings (Fig. 308). The veins of the wings are dark, which renders them prominent. In the males there is a yellowish spot just beyond the discal cell.

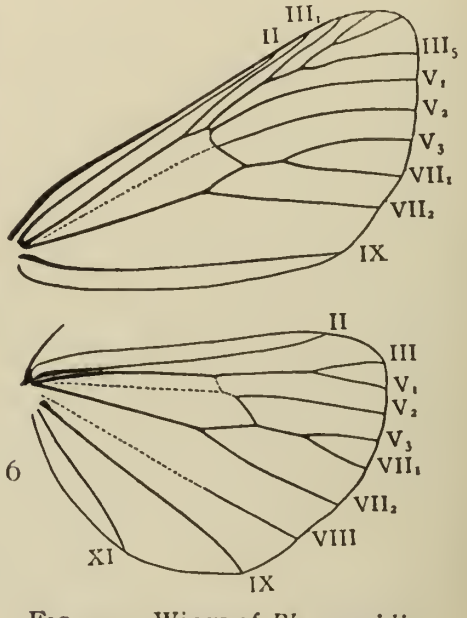


FIG. 309.—Wings of *Phryganidia.*

The venation of the wings

(Fig. 309) is very different from that of any other insect that occurs in this country.

The larvæ feed upon the leaves of live-oaks, and sometimes occur so abundantly as to almost strip the trees of their foliage. They are said to feed singly, and appear to make little if any use of the anal feet as a means of locomotion, generally carrying the last segment of the body elevated in the air.

Family NOTODONTIDÆ (No-to-don'ti-dæ).

The Prominents.

This family includes moths of moderate size, only a few of the larger ones expanding more than two inches. With these moths the body is rather stout and densely clothed with hair, and the legs, especially the femora, are clothed with long hairs. The wings are strong, and not very broad, the anal angle of the hind wings rarely reaching the end of the abdomen. In their general appearance many of these moths bear a strong resemblance to the Owlet Moths or Noctuidæ; but they can be easily distinguished from the Noctuids by the position of vein V_2 of the fore wings, which does not arise nearer to vein VII than to vein III, as it does in that family.

In some species the front wing has a prominence or backward-projecting lobe on the inner margin, which has suggested the common name of Prominents for these insects (Fig. 310). The name is more generally appropriate, however, for the larvæ, as a much larger proportion of them than of the adults bear striking prominences.

FIG. 310.—*Pheosia rimosa.*

The characteristic features in the structure of the wings are the following (Fig. 311): the fore wings have a single anal vein, the hind wings two; in both wings cubitus is apparently three-branched; and the subcosta of the hind wings does not make a sharp bend into the humeral angle as it does in the Geometridæ (Fig. 323). In some forms the basal part of vein V is more or less distinctly preserved; and in some an accessory cell is present.

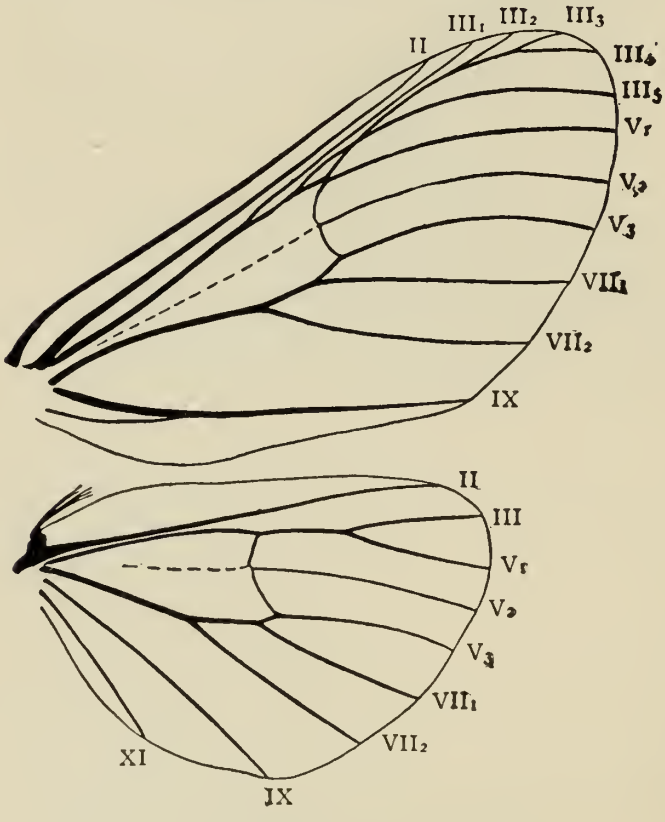


FIG. 311.—Wings of *Notodonta stragula*.

The larvæ feed upon the leaves of shrubs and trees. Our most common species live exposed; but some species live in folded leaves. They are either naked or thinly clothed with hairs. Many species have only four well-developed pro-legs, the anal pair being rudimentary, or transformed into elongated spikes. Some species are hump-backed; and spines or fleshy tubercles are often present. The transformations occur in slight cocoons or in the ground.

The family is a large one, more than one hundred species occurring in the United States. The following are some of the more common species:—

The Handmaid Moths, *Datana* (Da-ta'na).—Among the more common representatives of the Notodontidæ are certain brown moths that have the fore wings crossed with bars of a different shade (Fig. 312), and that bear on the

fore part of the thorax a conspicuous patch of darker color. In most of our species the fore wings are also marked with a dot near the center of the discal cell and a bar on the discal vein. These moths belong to the genus *Datana*. The common name, Handmaid, is a translation of the specific name of our most common species, *D. ministra* (D. mi-nis'tra). But as this species is now generally known as the Yellow-necked Apple-tree Worm, and as all of our species are dressed in sober attire as becomes modest servants, we have applied the term Handmaid Moths to the entire genus.

FIG. 312.—*Datana*.

The larvæ of the Handmaid Moths are easily recognized by their peculiar habits. They are common on various fruit and forest trees, but especially on apple, oak, and hickory. They feed in colonies; and have the habit of assuming the

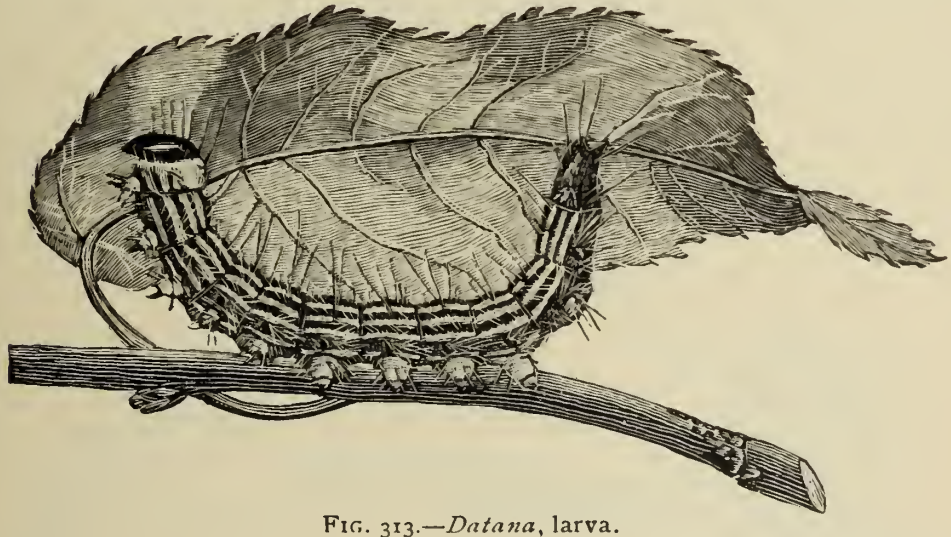


FIG. 313.—*Datana*, larva.

curious attitude shown in Figure 313. The body is black or reddish, marked with lines or stripes of yellow or white. Owing to the gregarious habits of these larvæ they can be easily collected from the trees they infest.

All of the species that we have studied agree in being single-brooded, the moths appearing in midsummer; the

eggs are laid in a cluster on a leaf; the larvæ are conspicuous in August and September. In some of the species the larvæ have the curious habit of leaving the branch upon which they are feeding when the time to molt arrives, the whole colony gathering in a large mass on the trunk of the tree, where the molt takes place. The pupa state is passed in the ground, in a very light cocoon or in none at all, and lasts about nine months in the species that we have bred.

The White-tipped Moth, *Edema albifrons* (E-de'ma al'bi-frons).—This beautiful moth, which is quite common, can be easily recognized by the accompanying figure (Fig. 314); the white patch, which extends along the costa of the fore wing for half the length from the tip, being very characteristic. The larva (Fig. 315) is quite common in the autumn on leaves of oak. It is smooth and shining, with no hairs; along each side of the back there is a yellow stripe, and between these, on the back, fine black lines on a pale lilac ground; on each side below the yellow stripe there are three black lines, the lowest one just above the spiracles. The head is orange-red; and there is an orange-red hump on the eighth abdominal segment.

FIG. 314.—*Edema albifrons.*

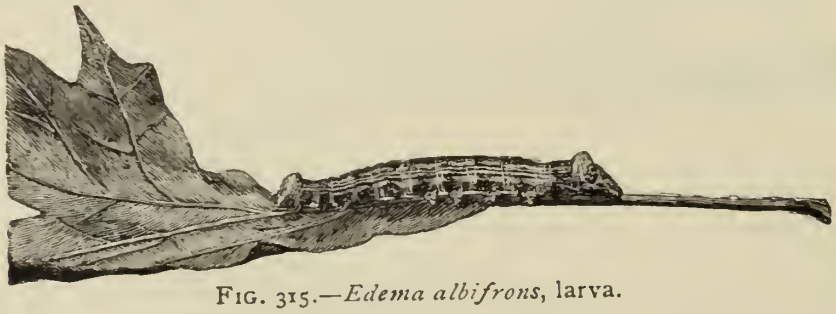


FIG. 315.—*Edema albifrons*, larva.

The Two-lined Prominent, *Seirodonta bilineata* (Seir-o-don'ta bi-lin-e-a'ta).—The larva of this species (Fig. 316) is much more apt to be observed than the adult. It is common in the latter part of the summer and in early autumn,

feeding on the leaves of oak, elm, and basswood. It measures when full grown about one and one half inches in length. Its ground-color is usually green, but sometimes claret-red. There is a pale yellow stripe along the middle of the back, and on each side a stripe of the same color. The course of these side stripes is very characteristic; passing back from the head, they converge on the prothorax; on the mesothorax and metathorax they are separated from the dorsal line only by a narrow band of red or purple; on the first abdominal segment they diverge to the lateral margin of the back, but converge again on the seventh and eighth abdominal segments. This yellow subdorsal line is bordered without by a milk-white stripe; and extending from this stripe over the side of the body there is a whitish shade which fades out below. The moth is ash-colored, with the fore wings crossed by two wavy lines between which the wing is darker; between the outer wavy line and the outer margin of the wing there is a faint band.

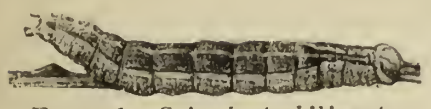


FIG. 316.—*Seirodonta bilineata*, larva.

The Red-humped Apple-worm, *Œdemasia concinna* (Œd-e-ma'si-a con-cin'na).—The larva of this species (Fig. 317) is common on apple and allied plants. The head is coral-

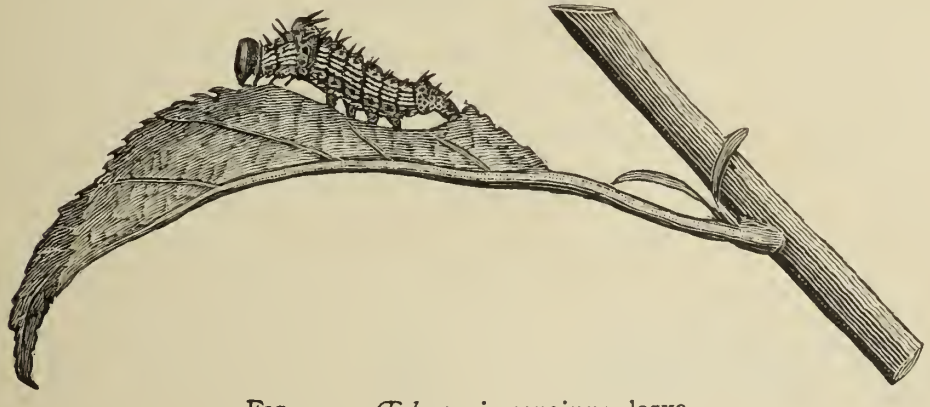


FIG. 317.—*Œdemasia concinna*, larva.

red, and there is a hump of the same color on the back of the first abdominal segment; the body is striped with slender black, yellow, and white lines, and has two rows of black

spines along the back, and other shorter ones upon the sides. When not eating, the larvæ remain close together, sometimes completely covering the branch upon which they rest. This species passes the winter in the pupa state. The adults appear in June and July.

The Mocha-stone Moths, *Ichthyura* (Ich-thy-u'ra).—To the genus *Ichthyura* belong several species of brownish-gray moths, whose fore wings are crossed by irregular whitish lines. It was these peculiar markings, resembling somewhat those of a moss-agate, that suggested the popular name given above. The larvæ feed on poplar and willow, and conceal themselves within nests made by fastening leaves together. Our most common species is the following:—

The Poplar Mocha-stone Moth, *Ichthyura inclusa* (I. inclu'sa).—The adult (Fig. 318) is a brownish-gray moth, with the fore wings crossed by three irregular whitish lines. The basal line is broken near the middle of the wing; and the intermediate one forms an inverted Y, the main stem of which joins the third line near the inner margin of the wing, making with it a prominent V. These lines are bordered without by rust-red; there is a chocolate-colored spot near the apex of the fore wings, and an irregular row of blackish dots near the outer margin. The hairs of the thorax form a prominent crest, the fore side of which is a rich dark brown. The hind wings are crossed by a wavy band, which is light without and dark within.

FIG. 318.—*Ichthyura inclusa.*

The eggs are nearly spherical and smooth; they are deposited in a cluster a single layer deep on a leaf (Fig. 319). When the larvæ hatch they make a nest either by fastening several leaves together or, as is the case when they infest poplar, by folding the two halves of a single leaf together; frequently in the latter case the tip of the leaf is folded in as shown in the figure. Within this nest the entire colony lives, feeding on the parenchyma, and causing the

leaf to turn brown. Later other leaves are added to this nest or additional nests are made among adjoining leaves. All of these infested leaves are securely fastened to the twig by bands of silk. When the larvæ become large they leave their nests at night to feed upon other leaves. These they entirely consume excepting the petioles, midribs, and larger

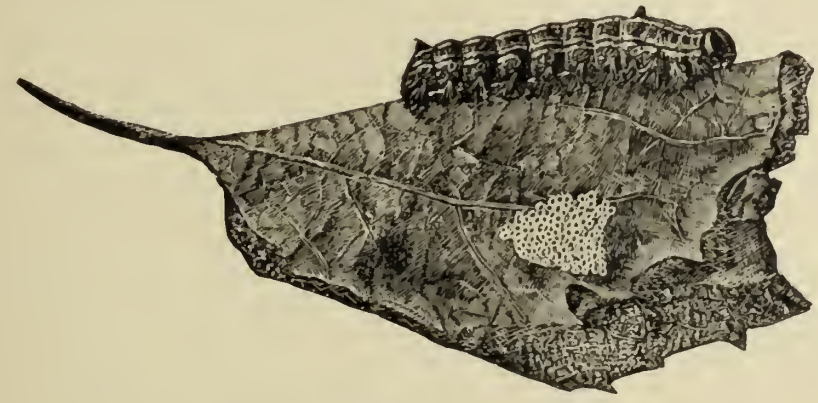


FIG. 319.—Eggs, larva, and nest of *Ichthyura inclusa*.

veins. We have seen on poplar a nest composed of only three leaves which contained one hundred and twenty-five half-grown larvæ; all of the leaves, about thirty in number, arising from the end of the branch bearing this nest had been consumed.

The full-grown larva measures one and one half inches in length. It is striped with pale yellow and brownish black, and bears a pair of black tubercles close together on the first abdominal segment, and a similar pair on the eighth abdominal segment. The cocoon is an irregular thin web; it is made under leaves or other rubbish on the ground. The insect remains in the pupa state during the winter, and emerges as a moth in the latter part of June or later. In the South this species infests willow as well as poplar, and is double-brooded.

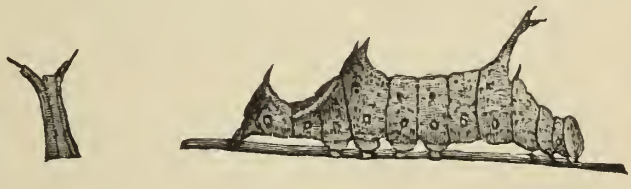


FIG. 320.— *Cœlodasys*, larva.

Among the most grotesque of larvæ belonging to this family are those of the genus *Cœlodasys*

(Cœ-lod'a-sys), of which we have several species. One of these is represented by Figure 320. At the left in the figure is shown a front view of the longest tubercle.

Superfamily GEOMETRINA (Ge-o-me-tri'na).

The Geometrids (*Ge-om'e-trids*), *or the Measuring-worms.*

The peculiar way in which the larvæ of Geometrids walk attracts general attention, and has won for them the name of Measuring-worms (Fig. 321). As children we had the dislike for "worms" that is common to people that are uneducated to the beauties of nature. All larvæ were "worms"; and we never thought of admiring their beautiful colors, or of watching them build interesting houses, or of keeping them till they spun their silken cocoons. But the measuring-worms were excepted from this dislike. We always found these delicate, greenish or yellowish caterpillars with their looping motion vastly interesting. We allowed them to measure our fingers with their little tickling feet, and we counted each length as a yard. We were always delighted with the way they had of standing on their hind legs, rearing the body up into the air, and moving the head around, as if looking at the scenery. And then, if one became frightened in any way, it would drop suddenly, suspended by a silken cord, which it seemed to have mysteriously concealed in its mouth; and down it would go, doubling and whirling around and around frantically until it reached the ground.

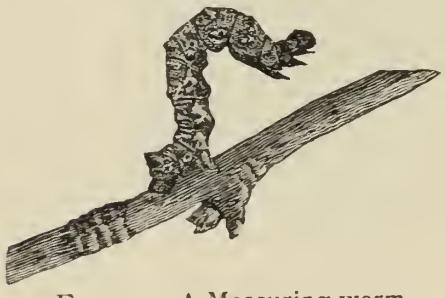


FIG. 321.—A Measuring-worm.

Sometimes we found these fellows on branches of trees, clinging by their hind legs, standing out straight, stiff, and motionless, and appearing like twigs of the tree. We had not heard then of protective resemblances, and did not know that the assuming of this strange attitude protected

these worms from the sharp-eyed birds. If so, we should have been still more interested in them; and we should have been even more so could some one have told us of the transformation of these loopers first into pupæ and then into beautiful moths. But in those days comparatively few people thought it worth while to study insects.

The larvæ of Geometrids have as a rule only the last two pairs of prolegs well developed; and hence, as the middle part of the body is not supported, they are unable to walk in the way that other caterpillars walk. It is probable, however, that the loss of the first three pairs of prolegs is the result of the looping gait rather than the cause of it. That is to say, the ancient Geometrid larvæ acquired the habit of looping, after which the prolegs under the middle of the body, being unnecessary and not used, dwindled away in succeeding generations. In the case of a few members of this family three or even four pairs of prolegs have been retained.

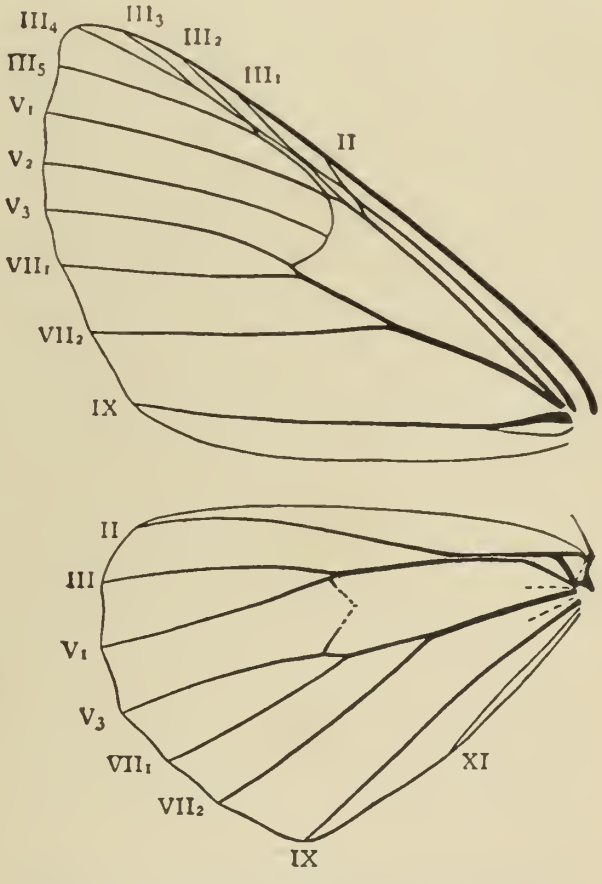


FIG. 322.—Wings of *Caripeta angustiorata*.

The Geometrid larvæ are mostly leaf-eating, and some species, as the Canker-worms, occur in such large numbers as to be serious pests.

The pupæ are slender, and some species are green or mottled in color in this state. The pupa state is passed in a very flimsy cocoon or in a cell in the ground.

The moths are of medium size, sometimes small, but only rarely very large. Usually the body is slender, and the wings broad and delicate in appearance. This appearance is due to the fineness of the scales with which the wings are clothed. These moths occur on the borders of woods and in forests, rarely in meadows and pastures. Their flight is neither strong nor long sustained. When at rest the wings are spread horizontally and scarcely overlap each other.

The distinguishing features in the venation of the wings of the Geometrina are that vein V_2 of the fore wings is not more closely joined to cubitus than to radius, cubitus being apparently three-branched, and that the basal part of vein II of the hind wings makes a prominent bend into the humeral angle of the wing (Figs. 322, 323).* Except in the more specialized forms where it has disappeared there is a rudiment of vein I of the hind wings. This usually extends from near the base of the frenulum to the angle in vein II (Figs. 322, 324). In *Eudule* (Fig. 323) and allied forms the rudiment of vein I lies some distance from the margin of the wing.

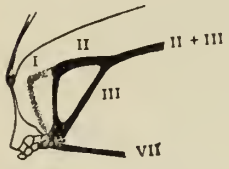


FIG. 323.—Humeral angle of hind wing of *Eudule*.

There occur in our fauna representatives of five families; these can be separated by the following table :—

A. Vein V_2 of the hind wings wanting, being represented merely by a fold in the wing (Fig. 327). p. 277. ENNOMIDÆ.

AA. Vein V_2 of the hind wings present.

B. Vein V_2 of the hind wings arising much nearer to vein V_1 than to vein V_3 (Fig. 343). Wings usually green. p. 287. GEOMETRIDÆ.

BB. Vein V_2 of the hind wings arising nearly midway between veins V_1 and V_3 or nearer to vein V_3 than to vein V_1. Wings rarely green.

* In the more specialized forms the humeral angle is greatly expanded (Fig. 343), and in some the frenulum is completely supplanted by it (Fig. 335) The loss of the frenulum in this family, however, occurs only in highly specialized forms ; while in that series of families that we have called the Frenulum-losers it has occurred in all except a very few extremely generalized forms.

C. Veins II and III of hind wings extending distinctly separate from each other, except that they are connected by a cross vein near the middle of the discal cell (Fig. 335). p. 282. HYDRIOMENIDÆ.

CC. Veins II and III of hind wings approximated or coalesced for a greater or less distance.

D. Veins II and III of the hind wings closely approximated but not coalesced along the second fourth (more or less) of the discal cell.

E. Veins III and V_1 of hind wings separating at or before the apex of the discal cell (Fig. 327). p. 277. ENNOMIDÆ.

EE. Veins III and V_1 of hind wings coalesced for a considerable distance beyond the apex of the discal cell (Fig. 324). p. 273. MONOCTENIIDÆ.

DD. Veins II and III of hind wings coalesced for a greater or less distance.

E. Veins II and III of the hind wings coalesced for a short distance near the beginning of the second fourth of the discal cell, thence rapidly diverging (Fig. 341). p. 286. STERRHIDÆ.

EE. Veins II and III of the hind wings coalesced to or beyond the middle of the discal cell (Fig. 334).

F. Fore wings with one or two accessory cells. p. 282. HYDRIOMENIDÆ.

FF. Fore wings without an accessory cell (*Alsophila*). p. 273. MONOCTENIIDÆ.

Family MONOCTENIIDÆ (Mo-noc-te-ni'i-dæ).

The Monocteniids (*Mon-oc-te'ni-ids*).

This family includes only a small number of North American species; but among them are those that are the most important to us from an economic standpoint of all the Geometrids.

The family is also of especial interest from a scientific point of view; for to it belong the most primitive forms of the Geometrina, certain genera, found in Australia, being closely allied to the Notodontidæ, according to the observations of Mr. Meyrick.

In the typical forms, vein V_2 of the hind wings is present, and veins II and III of the hind wings are closely approximate, but do not coalesce along the second fourth of the discal cell (Fig. 324). In many genera veins III and V_1 of the hind wings coalesce beyond the apex of the discal cell (Fig. 324). This character is of use in distinguishing certain members of this family from those of the Ennomidæ that retain vein V_2 of the hind wings. In that family a similar coalescence of veins III and V_1 does not take place till after the loss of vein V_2. In one of our genera veins II and III of the hind wings coalesce along the second fourth of the discal cell, as they do in the Hydriomenidæ; but the absence of an accessory cell in the fore wings at once distinguishes this genus from the Hydriomenids. The following species are our best known representatives of the family.

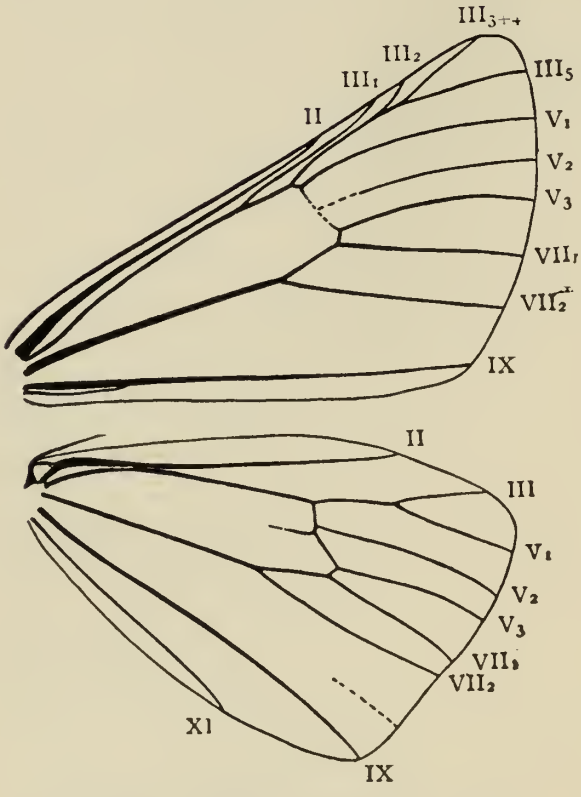


FIG. 324.—Wings of *Brephos infans*.

The Firstborn Geometer, *Brephos infans* (Bre'phos in'fans).—This interesting species has been found only in the northeastern part of our country; its range is from Labrador to New York. It is a blackish-brown moth with the fore wings marked with pinkish white and the hind wings with reddish orange (Fig. 325). The specimen figured is a male. In the female

FIG. 325.—*Brephos infans*, male.

the black border on the outer margin of the hind wings is narrower, and the subterminal light band on the fore wings is more distinctly marked. The early stages of this species are unknown; but the larvæ of European species feed upon birch and poplar. With these the prolegs are all present; but the first three pairs are stunted. As this is probably the most primitive Geometer occurring in our fauna, we suggest the popular name Firstborn for it. In Germany an allied species is known as the Jungfernkind.

Canker-worms.—In many parts of our country Canker-worms are extremely abundant. In such localities they are among the more important of insect pests, often completely stripping the foliage from fruit and shade trees. There are two distinct species of Canker-worms; but they resemble each other so closely that they were long confounded; and to this day they are distinguished only by entomologists. The two species agree in being loopers or measuring-worms in the larval state, in the possession of ample wings by the adult male, and in the adult female being wingless. They differ in structural characters, as indicated below, and also to a certain extent in habits. In one species the greater number of moths mature in the autumn and emerge from the ground at this season; in the other species the insects remain in the pupa state during the winter, emerging as moths in the spring. The two species are therefore appropriately designated as the Fall Canker-worm and the Spring Canker-worm respectively.

The Spring Canker-worm, *Paleacrita vernata* (Pal-e-ac'ri-ta ver-na'ta).—The eggs are ovoid in shape, and are secreted in irregular masses, usually under loose scales of bark or between the leaflets of the expanding buds. The larvæ hatch about the time the leaves expand, and become full grown in from three to four weeks. They vary greatly in color, and are marked on the back with eight narrow, pale, longitudinal lines which are barely discernible; the two lateral lines of each side are much farther apart than the others; and there are

no prolegs on the fifth abdominal segment. The pupa state is passed below the surface of the ground in a simple earthen cell, which is lined with very few silken threads. The adult moths usually emerge early in the spring before the leaves expand; but they sometimes appear late in the fall, or on warm days during the winter when the ground is thawed. In both sexes the adult of this species is distinguished by the presence of two transverse rows of stiff reddish spines, pointing backwards, on each of the first seven abdominal segments. In the male the venation of the wings very closely resembles that of *Brephos* (Fig. 324); veins II and III of the hind wings although closely approximate do not coalesce, and veins III and V_1 coalesce for a considerable distance beyond the apex of the discal cell.

The Fall Canker-worm, *Alsophila pometaria* (Al-soph'i-la pom-e-ta'ri-a).—The eggs appear as if cut off at the top, and have a central puncture and a brown circle near the border of the disk. They are laid side by side in regular rows and compact batches, and are generally exposed. They hatch in the spring at the time the leaves appear; and the larvæ mature in about three weeks. The larva is of a pale brownish color marked with dark brown and yellow; the body is marked on the back with six broad and very distinct pale lines, those of each side equidistant; and there is a pair of distinct prolegs on the fifth abdominal segment. As in the preceding species the pupa state is passed beneath the ground, but this species makes a perfect cocoon of fine densely spun silk. The adult moth usually emerges in the fall, generally beginning about the middle or latter part of October; although a considerable number come out of the earth in the winter during warm weather and in the spring. The moths of both sexes lack the abdominal spines characteristic of the Spring Canker-worm.

FIG. 326.—*Alsophila pometaria*, male.

The male is represented by Figure 326. In this species veins II and III of the hind wings coalesce for a considerable distance along the second fourth of the discal cell; and veins III and V_1 of the hind wings separate at the apex of the discal cell.

The two species of Canker-worms are sufficiently alike in habits to warrant our combating them by similar methods. The fact that in each the female is wingless and is thus forced to climb up the trunks of trees in order to place her eggs in a suitable place has suggested the method of defence that has been most generally used in the past. This is to place something about the trunks of the trees which will make it impossible for the wingless female to ascend them. Some viscid substance, as tar, printers' ink, or melted rubber, either painted on the trunk of the tree or upon a paper band which is tacked closely about the tree, is the means usually adopted. Many other devices have been recommended. In the use of this method of prevention, operations should be begun in the autumn, even when it is the Spring Canker-worm that is to be combated. For in this species some of the moths emerge in the fall or during the winter.

Although the method just described is still the most available one when tall shade-trees are to be protected, it is now rarely used in orchards. Here the spraying of the trees with Paris-green water soon after the leaves appear is found more practicable. This method has also the advantage of enabling the fruit-grower to reach other important pests, as the Codlin-moth, at the same time.

Family ENNOMIDÆ (En-nom'i-dæ).

The Ennomids (*En'no-mids*).

Nearly all of the members of this family can be easily recognized as such by the fact that vein V_2 of the hind wings is wanting, being represented merely by a fold. In a few species this vein has been preserved; these can be recog-

nized by the following combination of characters: Vein V_2 of the hind wings does not arise much nearer to vein V_1 than to vein V_3 (as it does in the Geometridæ), veins II and III of the hind wings are closely approximate *but do not coalesce* along the second fourth, more or less, of the discal cell (Fig. 327), and veins III and V_1 of the hind wings do not coalesce beyond the apex of the discal cell. This last character does not apply to the family as a whole, but merely to those that retain vein V_2 of the hind wings; in some of those in which this vein is lost, the coalescence of veins III and V_1 is carried beyond the apex of the cell.

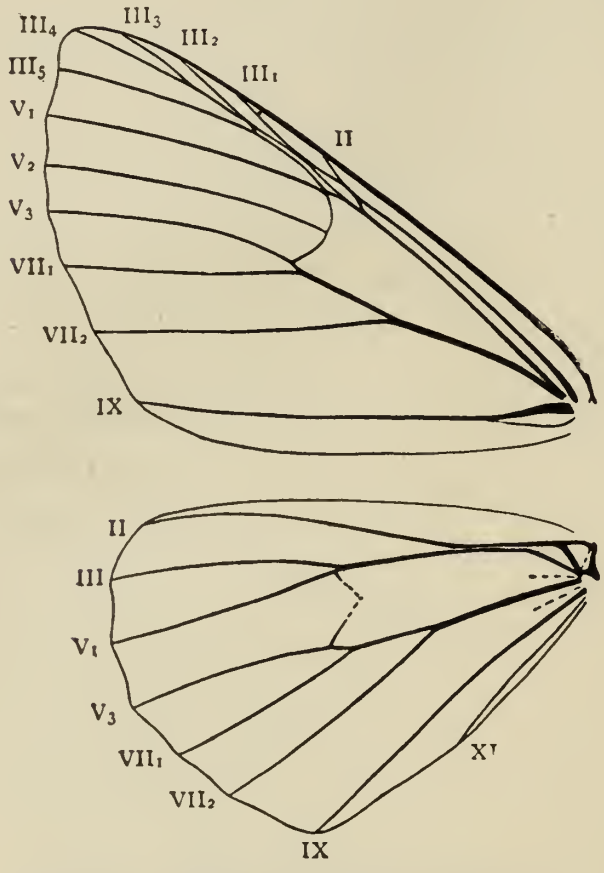


FIG. 327.—Wings of *Caripeta angustiorata*.

This is by far the largest of the families of the Geometrina and contains the greater number of our larger species. The following will serve as illustrations of it:—

FIG. 328.—*Ennomos magnarius*.

The Notched-wing Geometer, *Ennomos magnarius* (En'no-mos mag-na'ri-us), is one of the largest of our Geometrids. The larva is a common looper upon maple, chestnut, and birch trees, and measures about two and one third inches in length

when full grown. It spins a rather dense, spindle-shaped cocoon within a cluster of leaves. The moth (Fig. 328) is ochre-yellow with a reddish tinge. The wings are shaded towards the outer margin with brown, and are thickly spotted with small brown dots.

The Currant Span-worm, *Diastictis ribearia* (Di-as-tic'tis rib-e-a'ri-a).—There are several species of insects that are popularly known as currant-worms. The most common of these are larvæ of saw-flies, which can be easily recognized by the large number of prolegs with which the abdomen is furnished. In addition to the saw-flies there is a yellow looper spotted with black, which often appears in such great numbers on currant and gooseberry bushes as to suddenly strip them of their foliage. This larva has been named the Currant or Gooseberry Span-worm. When full grown it measures about one inch in length, and is of a bright yellow color, with white lines on the sides and with numerous black spots and round dots. It has only four prolegs. There is only a single brood; the larva matures in May or June; the pupa state lasts about a fortnight; the moth flies during the summer months and oviposits on the twigs of the plants; and the eggs remain unhatched till the following spring. The moth (Fig. 329) is pale yellow, with the wings marked by irregular dusky spots, which sometimes form one or two indefinite bands across them.

FIG. 329.—*Diastictis ribearia.*

FIG. 330.—*Cingilia catenaria.*

The Chain-dotted Geometer, *Cingilia catenaria* (Cin-gil'i-a cat-e-na'ri-a).—This moth

has snow-white wings marked with zigzag lines and with dots of black as shown in Fig. 330. The head is ochreous-yellow in front; and the thorax is yellowish at the base of the patagia. The moth flies during September and October. The larva feeds on various shrubs and trees. The pupa state is passed in a slight but well-formed web of yellow threads, which is formed between twigs or leaves, and through which the pupa can be seen.

The Evergreen Cleora, *Cleora semiclusaria* (Cle'o-ra sem-i-clu-sa'ri-a).—This beautiful moth (Fig. 331) is common in the vicinity of pines, spruce, fir, and hemlock during August and September. It varies from a smoky-ash color to almost snow-white; the wings are marked with black. The larva feeds on the leaves of Conifers. It is reddish yellow above, with lateral yellow bands below, while on each side are two pairs of black hair-lines. There are black spots above on the segments. When full grown it is a little more than an inch long and spins a loose cocoon among the leaves. The chrysalid is green with white stripes and is very pretty.

FIG. 331.—*Cleora semiclusaria.*

The Pepper-and-salt Currant-moth, *Biston cognataria* (Bis'ton cog-na-ta'ri-a).—This moth (Fig. 332) differs remarkably in appearance from most Geometrids, the body being stouter, and the wings appearing heavier. It can be easily recognized by its evenly distributed pepper-and-salt markings. The larva feeds on various plants, but is found most often on currant.

FIG. 332.—*Biston cognataria.*

The Lime-tree Winter-moth, *Erannis tiliaria* (E-ran'nis

til-i-a'ri-a).—This species (Fig. 333) resembles the Canker-worms in many particulars. The larva is a looper which infests both fruit and forest trees; and in the adult state the male has well-developed wings, while the female is wingless.

The eggs are oval, of a pale yellow color, and covered with a network of raised lines. They are thrust by the

FIG. 333.—*Erannis tiliaria.* (From the Author's Report for 1879.)

female under loose bark and in crevices on the trunk and large limbs. They hatch in May, and the larvæ attain their full growth in the latter part of June. The larva is yellow, marked with ten crinkled black lines along the top of the back; the head is rust-colored, and the venter yellowish white; when full grown it measures about one and one fifth inches in length. The pupa state is passed in the ground, from three to six inches below the surface. The moths issue in October, and then the wingless females ascend the

trees to oviposit as do the females of the Canker-worms. The female is represented in the lower left-hand part of the figure. She is grayish in color, with two black spots on the back of each segment except the last, which has only one. The male has buff fore wings, with a central spot and a band beyond the middle, while the hind wings are much lighter. This insect can be combated by the same methods as are used against canker-worms.

Family HYDRIOMENIDÆ (Hyd-ri-o-men'i-dæ).

The Hydriomenids (*Hyd-ri-o-me'nids*).

The Hydriomenids are easily recognized by the structure of their wings. In the fore wings the branches of radius anastomose so as to form one or two accessory cells; and in the hind wings veins II and III coalesce along the second fourth of the discal cell, the coalescence extending to or beyond the middle of the

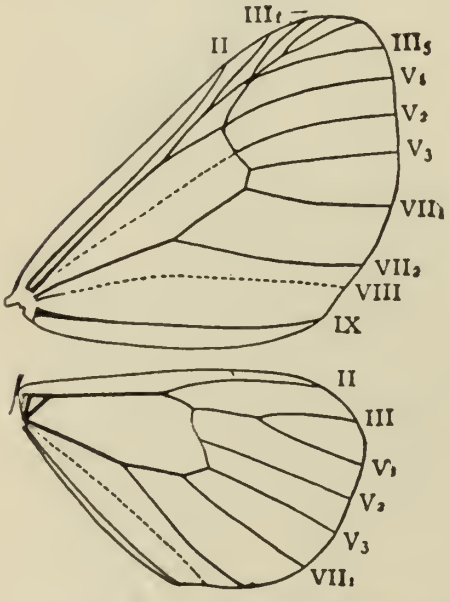


FIG. 334.—Wings of *Eudule mendica*.

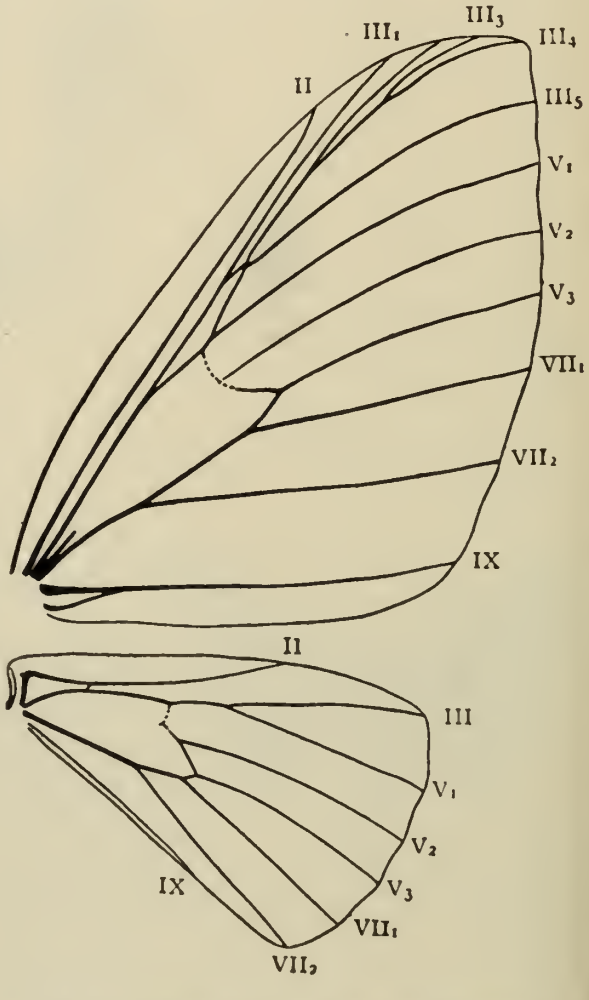


FIG. 335.—Wings of *Dyspteris abortivaria*.

discal cell (Fig. 334). The only exception to these characters known to us is shown by certain genera (e.g., *Heterophleps* and *Dyspteris*) in which, owing to a large expansion of the costal area of the hind wings, veins II and III have been pulled apart as it were, and are connected only by a cross-vein near the middle of the discal cell (Fig. 335). In a single genus (*Paleacrita*) not belonging to this family veins II and III of the hind wings coalesce to the middle of the discal cell; but this genus lacks the accessory cell in the fore wings characteristic of this family.

This family ranks second in size among the Geometrid families, and contains many common species.

The White-striped Black, *Euchœca albovittata* (Eu-chœ'ca al-bo-vit-ta'ta).—This beautiful little moth, which occurs from the Atlantic to the Pacific, is the most easily recognized member of the family. It expands about seven eighths of an inch, and is of a uniform black color, with a single, very broad white band extending across the fore wing from the middle of the costa to the inner angle, where it is usually forked. The fringe of the wings is white at the apical and inner angles of both pairs; sometimes the white is lacking on the inner angle of the hind wings. The early stages of this beautiful moth are unknown.

The Spear-marked Black, *Plemyria hastata* (Ple-myr'i-a has-ta'ta).—This is another black-and-white species, occurring from the Atlantic to the Pacific. It is much larger than the preceding, expanding one and four tenths inches. It is black, striped and spotted with white. It varies greatly as to the number and extent of the white markings. The most constant mark is a broad white band crossing the middle of the fore wings, and often continued across the hind wings. Near the middle of its course on the fore wing this band makes a sharp angle pointing outward; and just beyond the apex of this angle there is usually a white spot. This spot and angular band together form a mark shaped something like the head of a spear. In some speci-

mens the white predominates; other specimens are almost entirely black, excepting the spear-mark. According to European authorities the larva is brown or blackish brown, with a darker line along the middle of the back, and a row of horse-shoe-shaped spots on the sides. It feeds on birch and sweet gale. It is gregarious, a colony of larvæ spinning together the leaves of the food-plant, and thus forming a nest within which they live and feed. The larva has not yet been observed in this country.

The Scallop-shell Moth, *Calocalpe undulata* (Cal-o-cal′pe un-du-la′ta).—This is a pretty

FIG. 336.—*Calocalpe undulata.*

moth, with its yellow wings crossed by so many fine, zigzag, dark brown lines that it is hard to tell which of the two is the ground-color (Fig. 336). It lays its eggs in a cluster on a leaf near the tip of a twig of cherry, usually wild cherry. The larvæ make a snug nest by fastening together the leaves at the end of the twig; and within this nest (Fig. 337) they live, adding new leaves to the outside as more food is needed. The leaves die and become brown, and thus render the nest conspicuous. The larvæ are black above, with four white

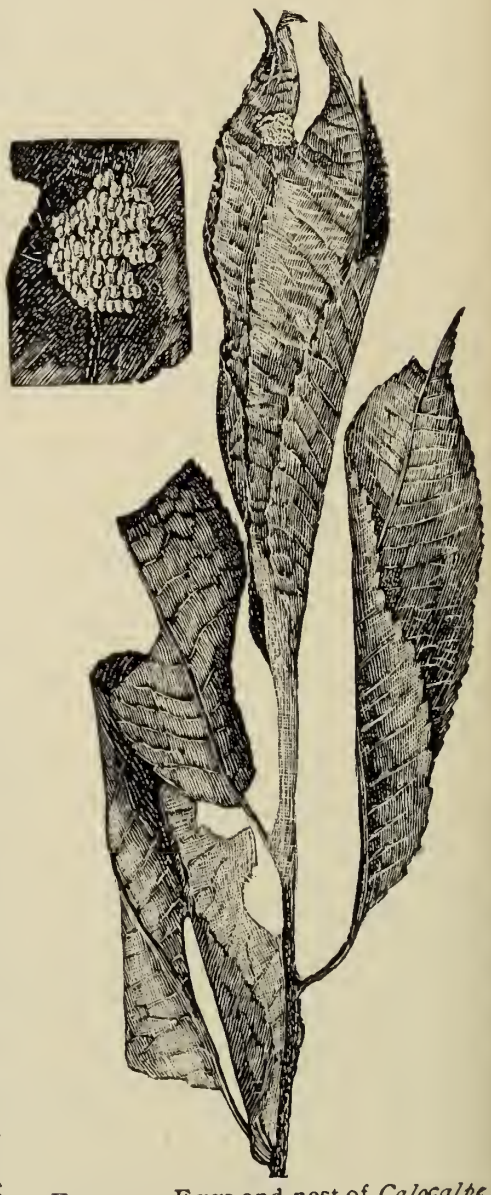


FIG. 337.—Eggs and nest of *Calocalpe undulata.*

stripes, and flesh-colored below. When full grown they descend to the ground to transform, and pass the winter in the pupa state.

The Diverse-line Moth, *Eustroma diversilineata* (Eus-tro'-ma di-ver-si-lin-e-a'ta).—This moth has pale ochre-yellow wings, with a brownish shade near the outer margin, and crossed by many diverging brown lines (Fig. 338). It varies from one inch and a half to two inches in expanse. We have often found this moth on the side of our room, resting on the wall, head downward, and with its abdomen hanging down over its head in a curious manner. The larva feeds on the leaves of grape. There are two broods; the first brood infests the vines during June; the second, in the autumn and early spring, wintering as larvæ.

FIG. 338.—*Eustroma diversilineata.*

FIG. 339.—*Eudule mendica.*

The Beggar, *Eudule mendica* (Eu-du'le men-di'ca).—One of the most delicate winged moths that we have in the Northern Atlantic States is this species (Fig. 339). Although the wings are yellowish white in color they are almost transparent. On the fore wings there are two transverse rows of pale gray spots, and a single spot near the outer margin between veins V_3 and VII_1. (This spot was indistinct in the specimen figured.) The moth is common in midsummer.

We do not know what fancy led the naturalist that described this species to name it *mendica*. But it seems appropriate now to call it a mendicant; for during the thirty years that have elapsed since the species was described it has not been allowed a position in its own family, but has been catalogued in the Lithosiidæ, although it was shown to be a Geometrid long ago.

The Bad-wing, *Dyspteris abortivaria* (Dys'pte-ris a-bor-ti-va'ri-a).—It is easy to recognize this moth (Fig. 340) by the peculiar shape of its wings, the hind wings being greatly reduced in size. It is of a beautiful pea-green color, with two white bands on the fore wings and one on the hind wings. Its color has led to its being placed heretofore in the Geometridæ; but the structure of its wings shows it to be an Hydriomenid. The larva feeds on the leaves of grape, which it rolls.

FIG. 340.—*Dyspteris abortivaria.*

Family STERRHIDÆ (Ster'rhi-dæ).

The Sterrhids (Ster'rhids).

The members of this family are most easily recognized by the venation of the hind wings (Fig. 341). In these veins II and III coalesce for a short distance near the beginning of the second fourth of the discal cell and then diverge rapidly. The greater number of our common species are of medium size, with whitish wings crossed by from two to four indistinct lines, and with the head black in front; some are pure white, and others are brown marked with reddish lines. About one hundred species have been found in this country.

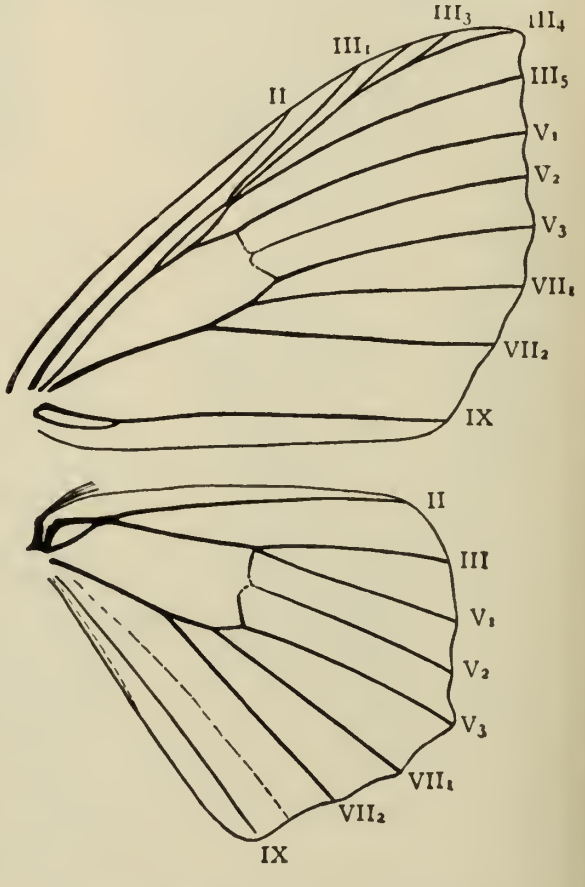


FIG. 341.—Wings of *Synelys ennucleata.*

The Chickweed Geometer, *Hæmatopis grataria* (Hæmat'o-pis gra-ta'ri-a).—This little moth (Fig. 342) is very common in our meadows and gardens during the summer and autumn months. Its wings are reddish yellow, with the fringes and two transverse bands pink. It is found from Maine to Texas. The larva feeds on the common chick-weed, *Stellaria media*.*

FIG. 342.—*Hæmatopis grataria.*

Family GEOMETRIDÆ (Ge-o-met'ri-dæ).

The Green Geometrids (*Ge-om'e-trids*).

As a rule the members of this family are bright green in color. And as we have but one other common Geometrid (*Dyspteris*, p. 286) of this color, the family may be well termed the Green Geometrids. The distinctive structure that characterizes this family is the fact that vein V_2 of the hind wings arises much nearer to vein V_1 than to vein V_3 (Fig. 343). In this family the tendency to expansion of the humeral angle of the hind wings, which is exhibited by all Geometrina, and which is correlated with the prominent bend into this angle of vein II, characteristic of this super-family, is

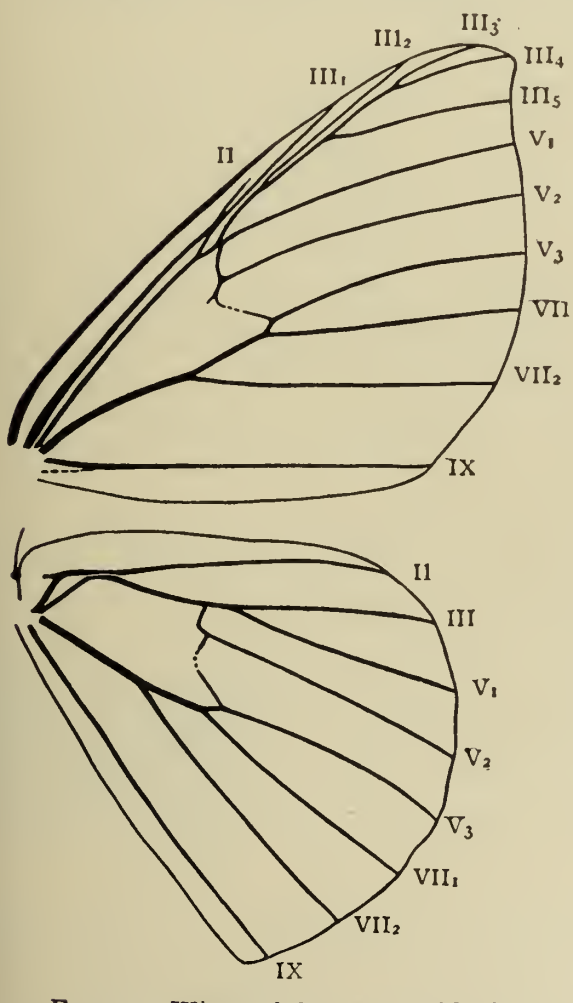


FIG. 343.—Wings of *Geometra iridaria.*

* This moth is figured and mentioned here because it is one of our most common species, and not as a typical illustration of the Sterrhidæ. It

carried farther than in the other families (except in the Dyspteris division of the Hydriomenidæ). In fact, in all of the forms known to the writer, the humeral angle extends a considerable distance beyond the frenulum. In the fore wings there is also a more marked migration of the base of vein V_2 towards radius than occurs in other Geometrid families. All these characteristics lead us to consider the Geometridæ the most specialized of the Geometrina.

The Raspberry Geometer, *Synchlora glaucaria* (Synchlo'ra glau-ca'ri-a).—The different species of green Geometrids resemble each other to such an extent that it is difficult to describe any one of them in a few words so that it can be surely distinguished. The wings of the Raspberry Geometer are of a delicate pale green color crossed by two lines of a lighter shade, and when expanded measure from one half inch to one inch, there being great variation in size of specimens. The larva is more easily distinguished on account of its curious habits. It feeds on the fruit and foliage of raspberry, but chiefly on the fruit. It covers its body by attaching to it bits of vegetable matter, so that it is masked beneath a tiny heap of rubbish.

Family AUZATIDÆ (Au-zat'i-dæ).

The Auzatids (*Au-za'tids*).

Only a single species belonging to this family is known to occur in this country. This is a small moth with delicate snow-white wings which expand from three fourths of an inch to one inch. This is *Eudeilinea herminiata* (Eu-deilin'e-a her-min-i-a'ta).

In the form of the body and in the structure of the wings (Fig. 344) the members of this family closely resemble the

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differs in important respects from the typical members of the family, and may belong elsewhere.

Drepanidæ. As in the Drepanidæ vein VII appears to be four-branched, and the course of vein II of the hind wings is similar in the two families, except that in the Auzatidæ this vein anastomoses with vein III beyond the discal cell; but the extent of this anastomosis varies greatly in different individuals of our species. In the Auzatidæ the apex of the fore wings is not sickle-shaped; and the branches of radius of the fore wings coalesce as in the Geometridæ, veins III_3 and III_4 coalescing to near the apex of the wing.*

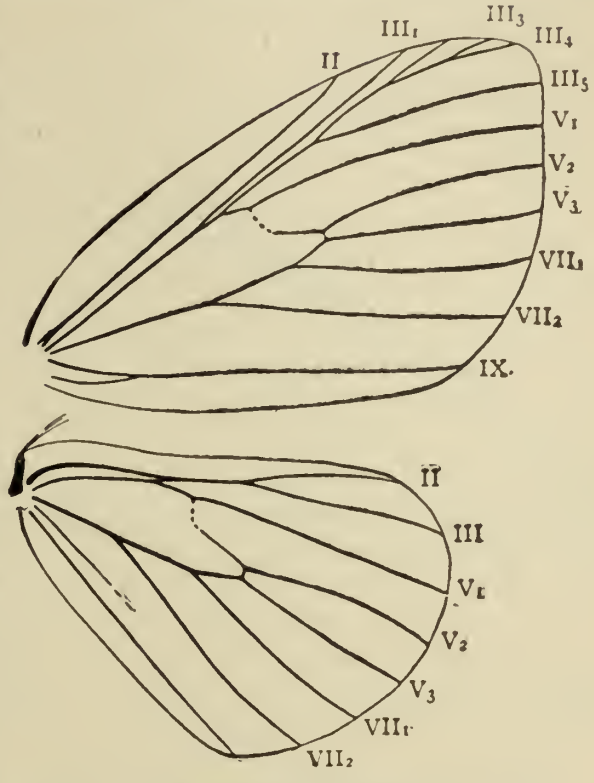


FIG. 344.—Wings of *Eudeilinea herminiata.*

Family DREPANIDÆ (Dre-pan'i-dæ).

The Hook-tip Moths.

The members of this family are small, slender-bodied moths, which can be easily recognized by the sickle-shaped apex of the front wings (Fig. 345). An approach to this form of wing is presented by some species of the Saturniidæ and by certain Geometrids. But the former are large, stout-bodied moths; and the latter differ in wing venation, cubitus of the fore wings appearing only

FIG. 345.—*Platypteryx arcuata.*

* In the Drepanidæ veins III_{2+3} and III_{4+5} do not coalesce from the apex of the discal cell outward (Figs. 346 and 347); but veins III_3 and III_4 anastomose for a greater or less distance near the apex of the wing, thus forming an accessory cell.

three-branched with them, whereas it appears four-branched in the Drepanidæ (Fig. 346).

Although the humeral angle of the hind wings is greatly developed in these moths, some of them retain the frenulum.

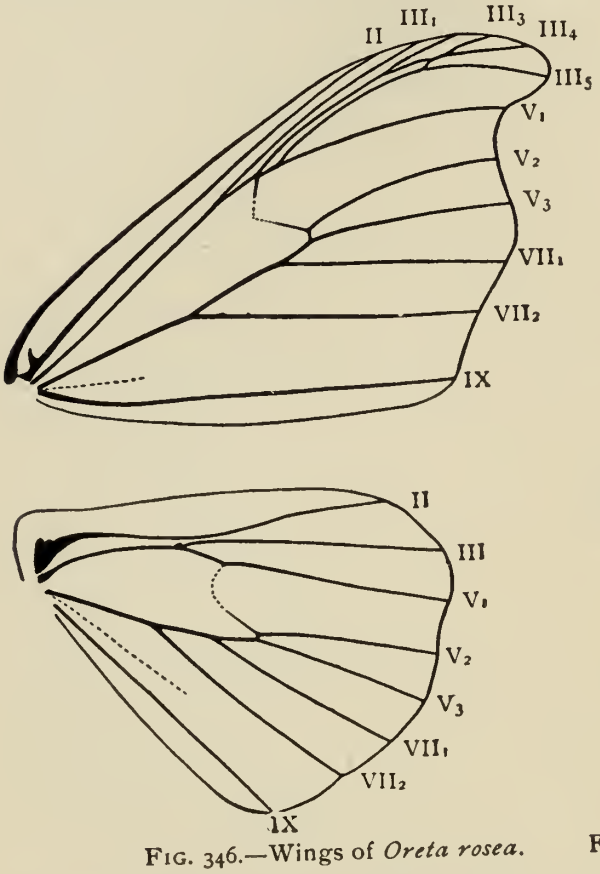


FIG. 346.—Wings of *Oreta rosea*.

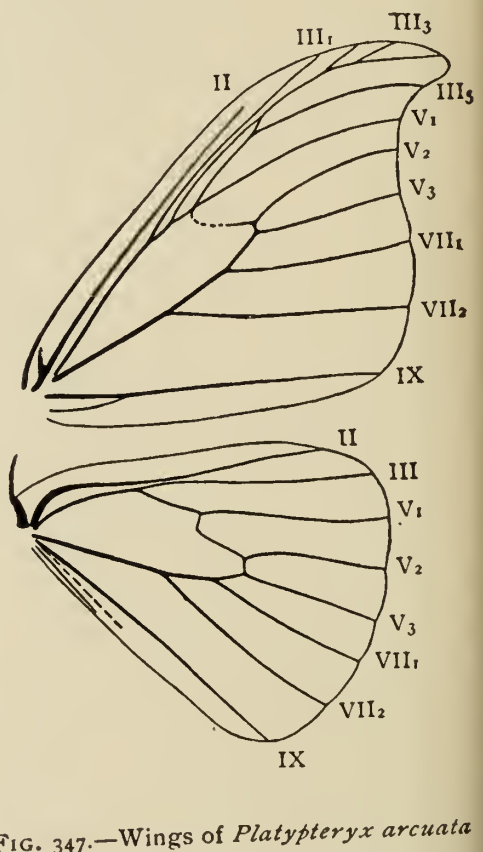


FIG. 347.—Wings of *Platypteryx arcuata*

When the frenulum is present it is borne at the end of a long thickened portion of the wing, so that it is at a considerable distance from the point where the wing is attached to the body (Fig. 347).*

The larvæ are remarkable in having the anal prolegs rudimentary, and the caudal segment prolonged into a more

* We class the Drepanidæ among the Frenulum-conservers, although many of them have lost the frenulum. Among the true Frenulum-losers the loss of the frenulum occurs while the race is still in a very generalized condition, no trace of a frenulum being found among these insects except a rudiment in the most generalized forms (*Bombyx*, *Cicinnus*). In the Drepanidæ, however, the frenulum is retained by very highly specialized forms. There is a striking similarity in this respect between this family and the more specialized Geometrids.

or less lizard-like tail. They live upon the foliage of shrubs and trees, and transform in a web between the leaves, or in a case in a rolled leaf.

Only a small number of species occur in our fauna; at present we know only eight; and all but one of these pertain to the eastern half of the continent.

Our most common Hook-tip Moth is *Platypteryx arcuata* (Pla-typ'te-ryx ar-cu-a'ta). This species is of a dirty white color marked with dark brownish lines and bands as shown in Figure 345. Its larva feeds upon white birch. *Platypteryx genicula* (P. ge-nic'u-la), another eastern species, resembles the preceding, but differs in being of a light ochre-yellow color and in the course of the wavy lines on the front wings. A third similar species occurs in California; this is *Platypteryx siculifera* (P. sic-u-lif'e-ra).

Family CYMATOPHORIDÆ (Cym-a-to-phor'i-dæ).

The Cymatophorids (*Cym-a-toph'o-rids*).

The Cymatophoridæ include moths of medium size, with elongated wings. The front wings are usually slightly widened at the inner angle (Fig. 348), and in our more common species are conspicuously marked with wavy or zigzag lines. The antennæ are filiform and more or less velvety or pubescent in the male, and the maxillæ are well developed. The moths fly by day, and when at rest fold their wings roof-like upon the abdomen.

FIG. 348.—*Thyatira scripta.*

The venation of the wings is illustrated by Figure 349. The important features to be noted are the following: In the front wing vein V_2 arises midway between veins V_1 and V_3; while in the hind wing vein V_2 arises much nearer to V_3 than to V_1. In the hind wing the subcosta and radius are distinct, and vein V_1 is joined to radius by a comparatively

long cross-vein (Fig. 349, *c. v.*), so that the two appear to separate before the end of the discal cell. In the males the tip of the frenulum is knobbed.

The larvæ are naked, and live upon the leaves of shrubs and trees. They often conceal themselves in a case, made by loosely fastening together leaves, or by folding a single leaf.

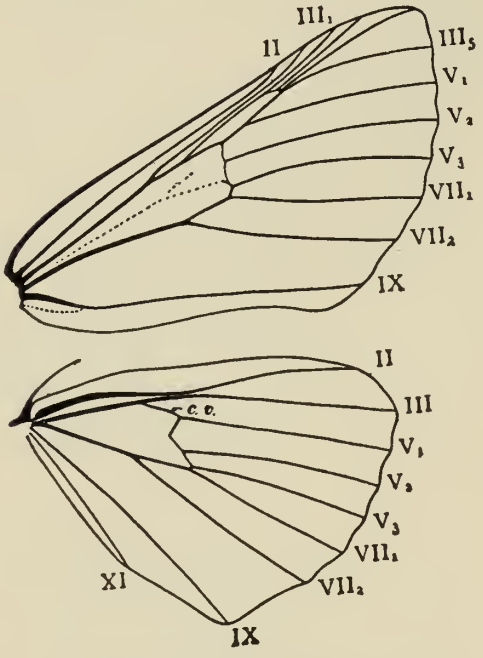


FIG. 349.—Wings of *Thyatira scripta*.

There are in our fauna representatives of only four or five genera belonging to this family; and the species that are common hardly exceed this number.

One of the more common species is *Thyatira scripta* (Thy-a-ti'ra scrip'ta). This has fawn-colored front wings, conspicuously marked with light bands and zigzag lines (Fig. 348). According to Thaxter, it lays its eggs late in July, in chains of five or six, on the leaves of raspberry, upon which the larvæ feed. The mature larva is rich yellow-brown, often almost black, with a distinct dorsal black line. The lateral portions are more yellow with blackish mottlings. When at rest the larva either elevates the cephalic and caudal ends of the body, like the Notodontids, so that the head rests upon the caudal segments, or conceals itself in a case formed by curling down the edge of a leaf. It makes a very slight cocoon late in August.

Another common species is *Pseudothyatira cymatophoroides* (Pseu-do-thy-a-ti'ra cym-a-toph-o-roi'des). This species is slightly larger than the preceding one, expanding nearly two inches. The front wings are silky gray tinted with rose. They are marked with a black spot at the base, a double or triple line, forming a black band at the end of

the basal third of the wing, two black spots on the outer half of the costa, a black spot at the inner angle, and a row of black points on the outer margin. There is a variety which lacks the black band and the four black spots. The larva of this species has been found on red oak; it is of a rich yellow-brown, mottled with fine dark lines, and lives in a case made by fastening leaves together. It makes a slight cocoon late in September; the adult emerges in June.

Family NOCTUIDÆ (Noc-tu'i-dæ).

The Owlet-moths or Noctuids (Noc'tu-ids).

This is the largest of all of the families of the Lepidoptera; more than eighteen hundred species are now known to occur in America north of Mexico. The great majority of the moths that fly into our houses at night, attracted by lights, are members of this family.

The nocturnal habits of these insects, and the fact that often when they are in obscurity their eyes shine brightly, have suggested the name of the typical genus (*Noctua*, from the Latin for owl), as well as the popular name Owlet-moths, by which they are known. Similar popular names have been given to them in several other languages.

Although there is almost no question regarding the limits of this family, as yet no structural character has been found by which they can be distinguished from certain other moths. Neither is there a general uniformity of appearance which we can use for this purpose, as the family includes great variations in size, form, and coloring. But most of the species are dull-colored moths of medium size.

The greatest difficulty arises in attempting to separate this family from the three following. Of these the first two (Pericopidæ and Agaristidæ) differ in their highly contrasting colors, as pointed out in the analytical table (p. 212, N and NN). In the third of these families (Lymantriidæ) the species have pectinate antennæ and do not have ocelli.

Only a few Noctuids have pectinate antennæ, and these, so far as they are known to the writer, lack ocelli.

The venation of the wings of a member of this family is represented by Figure 350. Vein V_2 of the fore wings arises much nearer to vein V_3 than to vein V_1; there is usually an accessory cell; and the anal vein may be forked towards the base or not. On the hind wings veins II and III usually coalesce for a short distance near the base of the wing; vein V_2 may be either well preserved or much weaker than the other veins; and there is considerable variation in the point of origin of this vein.

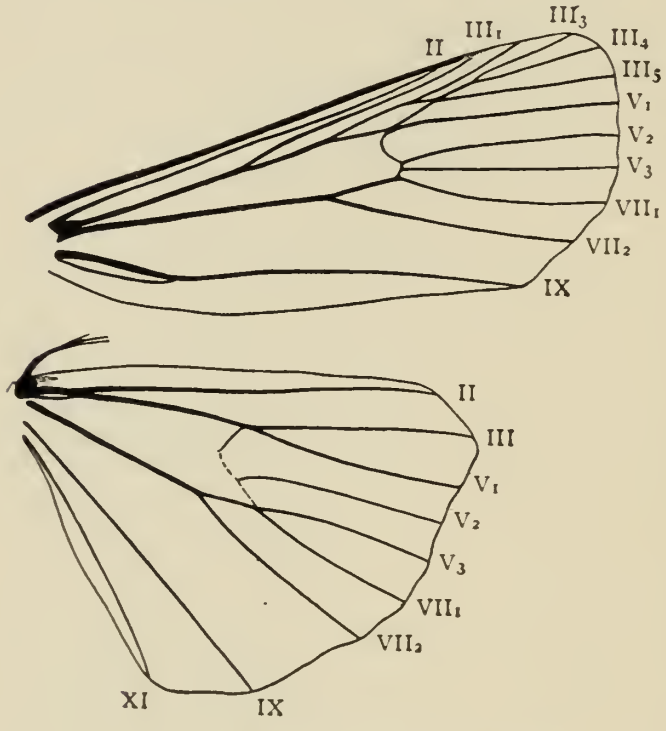


FIG. 350.—Wings of *Agrotis ypsilon*.

In the typical Noctuids, the body is large in proportion to the size of the wings; the front wings are strong, somewhat narrow, and elongated, the outer margin being shorter than the inner margin; and when at rest, the wings are folded upon the abdomen, giving the insect a triangular outline. The antennæ are thread-like, fringed with hairs, or brush-like, rarely pectinate in the males. Two ocelli are almost always present. The labial palpi are well developed, and in some species quite prominent. The maxillæ are quite long and stout in most species. The thorax is heavy and stout. In some species the scales on the dorsal surface of the thorax are turned up more or less, forming tufts.

The abdomen is conical and extends beyond the inner angle of the hind wings, when these are spread.

The majority of the larvæ are naked, of dull colors, and provided with five pairs of prolegs. As a rule they feed on the leaves of plants, but some are borers and some gnaw into fruits. Among them are some of the most important insects injurious to agriculture.

Although the Noctuidæ is a very large family, the efforts that have been made to divide it into subfamilies have not given satisfactory results. Many subfamilies have been indicated; but in most cases these proposed subfamilies appear to be merely groups of allied genera which cannot be distinguished by any common character from the other similar groups. In the following pages we have given illustrations of a large proportion of these groups, in order to show, as well as we can in a limited space, the variations in form included in this family. The sequence of groups adopted is that given in the latest catalogue of the family, that by Professor J. B. Smith; in some respects we doubt its being natural.

There is a group of moths, the Deltoids, which are placed at the foot of this family on account of their apparent relationship to the Geometrids and to the Pyralids. These moths are usually of dull colors and of medium size. The name Deltoids was suggested by the triangular outline of the wings when at rest, which is well represented by the Greek letter delta. When in this position the wings slope much less than with other Noctuids, the attitude being more like that assumed by the Geometrids; but the hind wings are more nearly covered than with the Geometrids. Many of the Deltoids have very long palpi, resembling in their size those of the Pyralids.

The Clover Hypena, *Hypena scabra* (Hy-pe'na sca'bra), is a common Deltoid. The larva feeds on the leaves of clover, and is a slender green worm. It measures when full grown two-thirds inch in length and only about one-tenth inch in

width in its widest part; it has a narrow subdorsal whitish line and a lateral one of the same color. When ready to transform it webs together several leaves and passes the pupa state in the nest thus made. The adult (Fig. 351) is a blackish-brown moth, with an irregular grayish shade on the outer half of the fore wings, and with very broad hind wings. The palpi, which are not well shown in the figure, are long, wide, and flattened; they project horizontally like a snout.

FIG. 351.—*Hypena scabra.*

The Hop-vine Hypena, *Hypena humuli* (H. hu'-mu-li), is closely allied to the preceding and has often been confounded with it. The larva feeds on the leaves of hop, and is sometimes a serious pest.

One of the most abundant of our Deltoids is *Pseudaglossa lubricalis* (Pseu-da-glos'sa lu-bri-ca'lis.) In this species (Fig. 352) the fore wings are chocolate-brown, crossed with yellowish lines; the hind wings are much lighter. The palpi are long; but they are curved over the head, so that they appear short when seen from above, as represented in the figure. The larva feeds on grass.

FIG. 352.—*Pseudaglossa lubricalis.*

Next to the Deltoids there is placed a group of moths which may be called the Similar-winged Owlets, from the fact that both pairs of wings are similarly marked by transverse lines. The group includes the largest of our Noctuids. The two following species will serve to illustrate this group.

FIG. 353.—*Homoptera lunata.*

The Lunate Similar-wing, *Homoptera lunata* (Ho-mop'-te-ra lu-na'ta.)—This is a brownish moth with marbled wings. It varies greatly in its markings. Figure 353 represents a

variety which has been named *edusa*, and which does not show well the lunate mark on the hind wings that probably suggested the name of the species. The larva feeds on the leaves of rose, willow, maple, plum, and other plants.

The Black Witch, *Erebus odora* (Er'e-bus o-do'ra).—The most magnificent in size of our Noctuids is this species (Fig. 354). There is much variation in the depth of coloring. The specimen figured is a female; in the male the fore wings are more pointed at the apex and the median band is

FIG. 354.—*Erebus odora*.

indistinct. It is a native of the West Indies, and is not known to breed in the United States. But specimens are found as far north as Canada and west to Colorado, and even in California. It is believed that these specimens have flown north from Cuba or from Mexico. Recently some observations have been made which seem to indicate that the moth does breed within our territory; but the question is not yet settled. Only isolated specimens are found in the North, and these in late summer or autumn.

Closely allied to the moths just described is another group of species with broad wings, of which the Two-lined Parallelia, *Parallelia bistriaris* (Par-al-lel'i-a bi-stri'a-ris) is a good example. This moth (Fig. 355) is brownish in color, and has the fore wings crossed by two parallel lines. The larva feeds on the leaves of maple.

FIG. 355.—*Parallelia bistriaris.*

The most striking in appearance of the Noctuids, if we except the Black Witch and one or two allied species, are the moths belonging to the genus *Catocala* (Ca-toc'a-la). These moths are of large size, often expanding three inches or more. The fore wings are usually brown or gray, marked with wavy or zigzag lines. The ground-color of the hind wings is black; but in many species these wings are conspicuously banded with red, yellow, or white. This peculiarity has suggested the name Underwings by which these

FIG. 356.—*Catocala ilia.*

insects are commonly known in England. The genus is a very large one; about eighty species are now known from this country; and many of these are extremely variable, so that about twice that number of named forms are now recognized. The Ilia Underwing, *Catocala ilia* (C. il'i-a), will serve as an example (Fig. 356). The larvæ of the

Underwings feed on the leaves of various forest-trees. Many species infest oak and hickory. By careful search both the adults and larvæ can be found resting on the trunks of these trees; but it needs sharp eyes to do it, as the colors of these insects are usually protective.

Among the more common Noctuids that occur in our meadows and pastures, and that fly up before us as we walk through them, are two species belonging to the genus *Drasteria* (Dras-te'ri-a). These may be called the Clover Looping-owlets; for the larvæ feed on the leaves of clover, and, as they have only three pairs of prolegs, they walk in a looping manner like the Geometrids. One of these species is *Drasteria erechtea* (D. e-rech'te-a). This moth (Fig. 357) has dark or light drab-gray fore wings, which are marked by two large dark bands, as shown in the figure. These bands are always separate, distinct, and well defined towards the inner margin in the male; in the female the markings are much less distinct.

FIG. 357.—*Drasteria erechtea.*

The other common species of this genus is *Drasteria crassiuscula* (D. cras-si-us'cu-la). In this species the fore wings have either a distinct violaceous brown or a red shade, with the two large dark bands very variable, often shading into the ground-color on the outer edge or coalescing near the inner margin; all the markings are equally distinct in both sexes.

There is a group of Noctuids containing about a score of genera in which the species differ markedly in appearance from the majority of the members of the family. In this group the moths are of small or moderate size; and some of them bear a strong resemblance to Tortricids. Many of the species are marked with bright colors, and especially with white. The two following species will serve to illus-

trate this group. *Chamyris cerintha* (Cham'y-ris ce-rin'tha) (Fig. 358) is white, with the fore wings marked with shades of olive, brown, and blue. The hind wings have a narrow border of dark scales, within which there may be a cloudy shade as shown in the figure, or this shade may be wanting. The larva feeds on the leaves of apple. The second of our illustrations of this group is *Acontia candefacta* (A-con'ti-a can-de-fac'ta) (Fig. 359). This species is also largely white, with the fore wings marked with shades of olive, brown, and yellow. The amount of yellow varies greatly in different specimens. The larva feeds on the leaves of *Ambrosia artemisiæfolia.*

FIG. 358. — *Chamyris cerintha.*

FIG. 359.—*Acontia candefacta.*

The Boll-worm, *Heliothis armigera* (He-li-o'this ar-mig'era).—This widely distributed pest is best known in its larval state ; but the larva varies so greatly in color and markings that it is difficult to prepare a description by which it can be recognized. The senior author has published colored figures of this insect, including five varieties of the larva, in his Report on Cotton-insects and also in the Report of the U. S. Department of Agriculture for 1879, Plate VIII. The larva when full grown measures about one and one half inches in length. It is often found feeding on the tips of ears of growing corn. It also frequently infests tomatoes, eating both the ripe and the green fruit. Occasionally it is found within the pods of peas and of beans eating the immature seeds. But the most serious of its injuries is to cotton. The larva bores into the pods or bolls of the cotton, destroying them. The injury thus done to the cotton crop is second in importance only to that done by the Cotton-worm, which destroys the foliage of the plant. Much can be done to check the injury of the Boll-worm to cotton by planting rows of corn in the cotton-field, and collecting the larvæ of the early broods from the ears of corn, thus reducing the

number of individuals in the later broods which infest the cotton.

The genus *Plusia* (Plu'si-a) includes a large number of species in which the fore wings are marked with metallic-colored scales. The most common form of this marking is a silvery spot shaped something like a comma near the centre of the wing. *Plusia simplex* (Fig. 360) is a well-known illustration of this genus. About sixty species of this genus have been described from North America. In some of the species the metallic markings cover a large proportion of the fore wings, and in others they are wanting. The larva of *Plusia brassicæ* (P. bras'si-cæ) feeds on cabbage and other *Cruciferæ*.

FIG. 360.—*Plusia simplex.*

In the cotton-growing States the most important insect pest is the Cotton-worm, *Aletia argillacea* (A-le'ti-a ar-gil-la'-ce-a). The adult of this insect (Fig. 361) is a brownish moth with its fore wings crossed with wavy lines of darker color and marked with a bluish discal spot and two white dots as shown in the figure. This moth is found in the Northern States and even in Canada in the latter part of the summer and in the autumn. But this occurrence in the North is due to migrations from the South, as the insect cannot survive the winter north of the Gulf States. The larva feeds on the foliage of cotton; and as there are five or six generations in a year, the multiplication of individuals is very rapid, and the injury to the cotton great. Detailed descriptions and colored figures of this insect in its different stages are given in the works cited above in the description of the Boll-worm. The best known way of combating this pest is by the use of Paris green.

FIG. 361.—*Aletia argillacea.*

The Hooded Owlets, *Cucullia* (Cu-cul'li-a).—We have several common grayish moths, in which the fore wings are marked with numerous irregular dashes of dark color, and in which the thorax is furnished with a prominent tuft of scales. These moths belong to the genus *Cucullia*. Figure 362 represents *Cucullia speyeri* (C. spey'er-i). These insects evidently have the power of moving this tuft of scales; for sometimes it projects forward over the head as shown in the figure, while in other specimens of the same species it will be directed backward; in this case it is much less conspicuous. The larvæ of the Hooded Owlets feed upon the leaves of goldenrod and other Compositæ.

FIG. 362.—*Cucullia speyeri.*

The Scalloped Owlet, *Scoleopteryx libatrix* (Scol-e-op'ter-yx li-ba'trix).—This moth is easily recognized by the shape of the wings, the outer margins of which are deeply cut and scalloped (Fig. 363). The color of the fore wings is soft brownish gray, slightly powdered with rust-red, and frosted with white along the costa. There is an irregular patch of rust-red reaching from the base to the middle of the wing, a single, white, transverse line before the middle, and a double one beyond the middle. The larva feeds on willow. This species is found in all parts of the United States and in Europe.

FIG. 363.—*Scoleopteryx libatrix.*

FIG. 364.—*Amphipyra pyramidoides.*

The American Copper Hindwing, *Amphipyra pyramidoides* (Am-phip'y-ra pyr-a-mi-doi'des).—The fore wings of this moth (Fig. 364) are dark brown, shaded with paler brown, and with dots and wavy lines of a glassy gray or dull whitish

hue. The hind wings, except the costal third, are reddish, with more or less of a coppery lustre. This suggests the popular name. A closely-allied species found in Europe is known as the Copper Underwing; but we prefer to reserve the name Underwing for the species of Catocala. The larva feeds on the leaves of grape and Virginia-creeper.

FIG. 366.—*Leucania unipuncta*, larva.

The Many-dotted Apple-worm, *Balsa malana* (Bal'sa ma-la'na).—In June, and again in August or September, there is sometimes found on apple-leaves, in considerable numbers, a rather thick, cylindrical, light-green worm, an inch or more in length, with fine, white, longitudinal lines and numerous whitish dots. These are the larvæ of the little moth represented by Figure 365. The fore wings of this moth are ash-gray, marked by irregular, blackish lines. The larvæ feed on the leaves of many other trees besides apple. The moth has been found throughout the eastern half of our country.

FIG. 365 — *Balsa malana.*

The Army-worm, *Leucania unipuncta* (Leu-ca'-ni-a u-ni-punc'ta).—The Army-worm is so called because it frequently appears in great numbers, and, after destroying the vegetation in the field where the eggs were laid, marches like an army to other fields. This insect occurs throughout the United States east of the Rocky Mountains, and is present every year; but it attracts attention only when it appears in great numbers. The larva (Fig. 366) is one and one-half inches long when full grown, and is striped with black, yellow, and green. The adult is of a dull brown color, marked in the center of each fore wing with a distinct white spot (Fig. 367). In seasons of serious outbreak of this pest it usually appears first in limited areas, in meadows or pastures.

If it is discovered before it has spread from these places it can be confined by surrounding the field with a ditch, or it may be destroyed by spraying the grass with Paris-green water. Ordinarily, however, the worms are not observed until after they have begun to march and are wide-spread. In such cases it is customary to protect fields of grain in their path by surrounding them with ditches with vertical sides; it is well to dig holes like post-holes at intervals of a few rods in the bottom of such ditches. The worms falling into the ditch are unable to get out, and crawl along at the bottom and fall into these deeper holes. We have seen these insects collected by the bushel in this way.

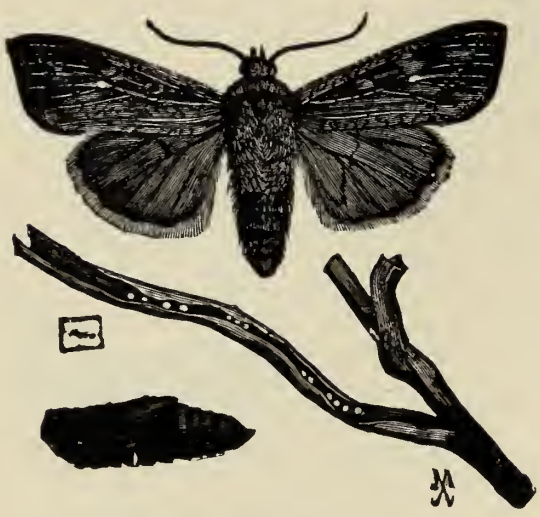


FIG. 367.—*Leucania unipuncta.*

The Diver, *Bellura gortynides* (Bel-lu'ra gor-tyn'i-des).—One of the most remarkable exceptions to what are usually the habits of members of this order is presented by the larva of this species. This larva is able to descend into water and remain there for a long time. It lives in the leaf-stalks of the pond-lily. It bores a hole from the upper side of the leaf into the petiole, which it tunnels in some instances to the depth of two feet or more below the surface of the water. This necessitates its remaining below the surface of the water while feeding. The writer has seen one of these larvæ remain under water voluntarily for the space of a half-hour. The tracheæ of these larvæ are unusually large, and we believe that they serve as reservoirs of air for the use of the insect while under water. The form of the hind end of the larva has also been modi-

FIG. 368.—*Bellura gortynides.*

fied, so as to fit it for the peculiar life of the insect. The last segment appears as if the dorsal half had been cut away; and in the dorsal part of the hind end of the next to the last segment, which, on account of the peculiar shape of the last segment, is free, there open a pair of spiracles much larger than those on the other segments. When not feeding the larva rests at the upper end of its burrow, with the segment bearing these large spiracles projecting from the water. The adult insect is a brownish moth which varies greatly in size and markings. Figure 368 represents what seems to be the more common form.

The Zebra Caterpillar, *Mamestra picta* (Ma-mes'tra pic'ta).—Cabbage and other garden vegetables are often subject to the attacks of a naked caterpillar, which is of a light yellow color, with three broad, longitudinal, black

FIG. 369.—*Mamestra picta*, larva.

FIG. 370.—*Mamestra picta*.

stripes, one on each side and the third on the top of the back. The stripes on the sides are broken by numerous pure white lines (Fig. 369). It passes the winter in the pupa state. The adult (Fig. 370) has dark chestnut-brown fore wings and pale yellowish hind wings.

Cut-worms.—Few pests are more annoying than the rascally little harvesters that nightly, in the spring, cut off our corn and other plants before they are fairly started. There are many species of these cut-worms, but they are all the larvæ of Owlet-moths. In general their habits are as follows: The moths lay their eggs during midsummer. The larvæ soon hatch, and feed upon the roots and tender shoots of herbaceous plants. At this time, as the larvæ are small and their food is abundant, they are rarely observed. On the

approach of cold weather they bury themselves in the ground and here pass the winter. In the spring they renew their attacks on vegetation; but now, as they are larger and in cultivated fields the plants are smaller, their ravages quickly attract attention. It would not be so bad if they merely destroyed what they eat; but they have the unfortunate habit of cutting off the young plants at the surface of the ground, and thus destroy much more than they consume. They do their work at night, remaining concealed in the ground during the daytime. When full grown they form oval chambers in the ground in which they pass the pupa state. The moths appear during the months of June, July, and August.

There are some exceptions to these generalizations: some species of cut-worms ascend trees during the night and destroy the young buds; some pass through two generations in the course of a year; and a few pass the winter in the pupa state.

Cut-worms can be destroyed by poisoned baits of fresh clover or other green vegetation, or with poisoned dough made of bran. Much can be done by making holes in the ground with a sharpened stick, as a broom-handle. The holes should be vertical, a foot deep, and with smooth sides. On the approach of day the cut-worms will crawl into such holes to hide, and will be unable to crawl out again. Climbing cut-worms can be jarred from the trees during the night, and caught upon sheets, and then destroyed.

FIG. 371.—*Noctua c-nigrum.*

One of our cut-worms, which is known as the Spotted Cut-worm, is the larva of the Black-c Owlet, *Noctua c-nigrum* (Noc'tu-a c-ni'grum). This moth (Fig. 371) is one of the most common species attracted to lights. It occurs throughout our country and in Europe.

At the end of the Noctuid series there is placed a group

of genera, which contain species that differ in appearance from other Noctuids, the larvæ of many being hairy like those of Arctiids. The fore wings of the moths are generally light gray with dark spots, and in many species have a dagger-like mark near the anal angle. On this account these moths have received the name Daggers.

The Ochre Dagger, *Acronycta morula* (Ac-ro-nyc'ta mor'u-la).—This moth (Fig. 372) is pale gray with a yellowish tinge. Besides the black line forming part of the dagger near the anal angle of the fore wing, there is a similar black line near the base of the wing, and a third near the outer margin between veins V_1 and V_2. The larva feeds on elm and basswood. When full grown it is mottled brown and greenish like the bark, it is clothed with but few scattered hairs, and has a hump on the first, fourth, and eighth abdominal segments.

FIG. 372.—*Acronycta morula.*

FIG. 373.—*Acronycta americana*, larva.

The American Dagger, *Acronycta americana* (Ac-ro-nyc'ta a-mer-i-ca'na).—This is a gray moth resembling in its general appearance the preceding, but with the black lines on the fore wings much less distinct. Its larva, however, is very different (Fig. 373). This larva looks like an Arctiid, being densely clothed with yellow hairs. But these hairs are scattered over the surface of the body instead of growing from tubercles, as with the larvæ of Arctiids. Along

the sides of the body and at each end are a few scattered hairs that are longer than the general clothing, and there are two pairs of long black pencils borne by the first and third abdominal segments, and a single pencil on the eighth abdominal segment. When at rest the larva remains curled sidewise on a leaf, as shown in the figure. It feeds on maple, elm, and other forest trees.

The Witch-hazel Dagger, *Acronycta hamamelis* (Ac-ro-nyc'ta ham-a-me'lis).—In the latter part of summer and in autumn the larva of this species is common on the leaves of witch-hazel, oak, and other forest trees. It differs greatly in appearance from the preceding species, being nearly naked (Fig. 374). When at rest it usually lies curled as shown in the figure. It varies in color from light yellow to reddish brown. Its most characteristic feature is a double row of milk-white spots along the middle of the back.

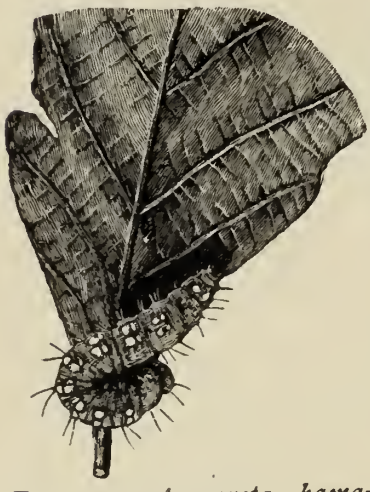


FIG. 374.—*Acronycta hamamelis*, larva.

Family LYMANTRIIDÆ (Lym-an-tri'i-dæ).

The Tussock-moths.

The larvæ of these moths are among the most beautiful of our caterpillars, being clothed with brightly-colored tufts of hairs; and it is to this characteristic clothing of the larvæ that the popular name Tussock-moths refers.

The adult moths are much plainer in appearance than the larvæ; and in the genus *Notolophus*, to which our most common species belong, the females are practically wingless, the wings being at most short pads, of no use as organs of flight.

The Tussock-moths are of medium size, with the antennæ of both sexes when winged pectinated, those of the males

very broadly so; the wingless females have serrate or narrowly pectinate antennæ. The ocelli are wanting. The legs are clothed with woolly hairs; when the insect is at rest the fore legs are usually stretched forward, and are very conspicuous on account of these long hairs. The venation of the wings is represented by Figure 375; in this respect these moths are very similar to the Noctuids; in fact we have been unable to find as yet any constant feature in the structure of the wings of either family that will serve to separate the two. But in the Lymantriidæ the antennæ are pectinate and the ocelli are absent; while in the Noctuidæ the antennæ are usually simple and the ocelli are usually present; and when the antennæ are pectinate the ocelli, in all cases known to us, are present: in this way a distinction is preserved between the two families. Although it is hard to find a distinction between the two that can be put into words, the general appearance of the Tussock-moths is very different from that of the Noctuids, and entomologists have no difficulty in deciding to which family any species belongs. The Tussock-moths are chiefly nocturnal; but the males of *Notolophus* fly in the daytime.

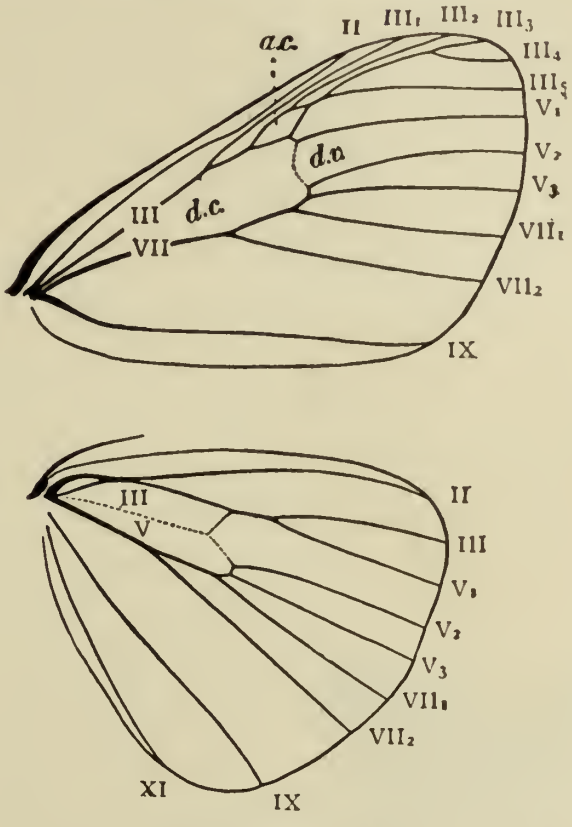


FIG. 375.—Wings of *Notolophus leucostigma*.

The larvæ of our native species are very characteristic in appearance. The body is hairy; there are several con-

spicuous tufts of hairs on the dorsal aspect of the abdomen, and at each end of the body there are long pencils of hairs; on the sixth and seventh abdominal segments there is on the middle of the back of each an eversible gland supposed to be a scent-organ similar to the osmateria in the larvæ of Papilio, and it is stated that a fine spray of liquid is sometimes thrown from them.

Excepting a few rare forms, our native species fall into two genera—*Notolophus* and *Parorgyia*. In *Notolophus* the males have short, broad wings; the females are nearly wingless. In *Parorgyia* both sexes are winged, and the wings are relatively longer than in *Notolophus*.

Our most common species belong to *Notolophus*. Of this genus the three best-known species are the following:—

The White-marked Tussock-moth, *Notolophus leucostigma* (No-tol'o-phus leu-co-stig'ma).—This is our most common representative of the family. It frequently occurs in such great numbers that it seriously injures the foliage of shade-trees and orchards. The male (Fig. 376) is of an ashy gray color; the fore wings are crossed by undulated bands of darker shade and bear a conspicuous white spot near the anal angle. The female is white and resembles a hairy grub

FIG. 376.—*Notolophus leucostigma.*

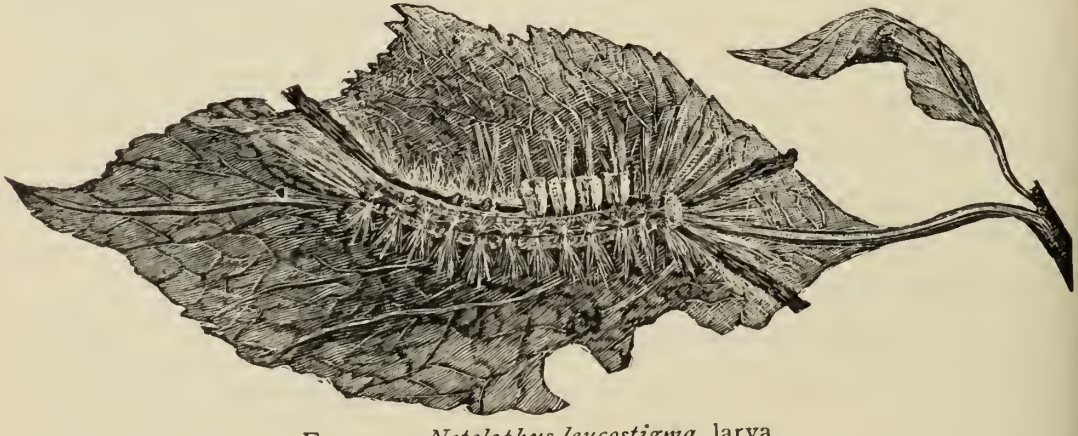


FIG. 377.—*Notolophus leucostigma*, larva.

more than a moth. She emerges from her cocoon and after pairing lays her eggs upon it, covering them with a

frothy mass. The larva (Fig. 377) is one of the most beautiful of our caterpillars. The head and the glands on the sixth and seventh abdominal segments are bright vermilion-red. There is a velvety black dorsal band, bordered with yellow subdorsal stripes; and there is another yellow band on each side just below the spiracles. The prothorax bears on each side a pencil of long black hairs with plume-like tips; a similar brush is borne on the back of the eighth abdominal segment, and the first four abdominal segments bear dense brush-like tufts of cream-colored or white hairs.

When this insect becomes a pest the larvæ can be destroyed by spraying the infested trees with Paris-green water; or the egg-bearing cocoons can be collected during the winter and destroyed. These cocoons are attached to the trunks of the trees and to neighboring objects, or to twigs. In the latter case they are usually partially enclosed in a leaf. Cocoons not bearing eggs should not be destroyed, as many of them contain parasites. Owing to the wingless condition of the female this pest spreads slowly.

The Well-marked Tussock-moth, *Notolophus definita* (N. def-i-ni'ta).—The male, like that of the preceding species, is of an ashy gray color; but the markings of the fore wings are much more distinct. The female is light brown. She lays her eggs in a mass on her cocoon, covering them with hair from her body. The larva closely resembles the preceding species in the form and arrangement of its tufts of hair, but differs markedly in color, being almost entirely light yellow. There is a dusky dorsal stripe and a velvety black spot behind each of the tufts of the first four abdominal segments. The head and the glands on the sixth and seventh abdominal segments are, like the body, light yellow.

The Old Tussock-moth, *Notolophus antiqua* (N. an-ti'qua). —The male is of a rust-brown color; the fore wings are crossed by two deeper brown bands and have a conspicuous white spot near the anal angle. The body of the grub-like female is black, clothed with yellowish white hairs; she lays

her eggs on her cocoon, but, unlike the two preceding species, does not cover them with anything. The larva differs from either of the preceding in having an extra pair of pencils of plume-like hairs arising from the sides of the second abdominal segment; the head is jet-black; the glands on the sixth and seventh abdominal segments are vermilion-red or sometimes bright orange; and the tubercles on the sides of the back of the second and third thoracic and the sixth and seventh abdominal segments are orange-red or yellow margined with pale yellow.

The Gipsy Moth, *Porthetria dispar* (Por-the'tri-a dis'par).—This is a European species which has been introduced into Massachusetts. It has become such a serious pest that the Legislature of that State has appropriated a large sum of money to be expended in efforts to eradicate it; this work is now going on. The male is yellowish brown; the female, white (Fig. 378). In each the fore wings are crossed by many dark lines and bear a black lunule on the discal vein. The specimen figured is unusually small. The eggs are laid in a mass on any convenient object and are covered with hair from the abdomen of the female. The larva differs greatly in appearance from that of the preceding genus, lacking the peculiar pencils and tufts of hair; but the characteristic glands of the sixth and seventh abdominal segments are present and are red. The body is dark brown or black, finely reticulated with pale yellow, and with narrow yellow dorsal and subdorsal lines. On the dorsal aspect of each segment there is a pair of prominent, rounded tubercles bearing spiny black hairs. The first five pairs of these tubercles are bluish, the others dark crimson-red. There are also two rows of tubercles on each side of the body which bear longer hairs.

FIG. 378.—*Porthetria dispar*, female.

Family AGARISTIDÆ (Ag-a-ris'ti-dæ).

The Wood-nymph Moths.

These gayly-dressed moths are a delight to the collector. We have but few species of them in this country, and an even smaller number are common. These moths are either black with large, white or yellow, rounded patches upon the wings, or they have the front wings white, margined with brown, and the hind wings pale yellow. They are chiefly day-flying; but some of them are attracted to lights at night.

The shape of the antennæ varies greatly in the different genera. In *Euthisanotia* the antennæ are filiform; in *Alypia* slightly enlarged near the tip; and in *Psychomorpha* they are filiform in the female and pectinated in the male. The maxillæ are moderately well developed and spirally rolled. The venation of the wings (Fig. 379) is very similar to that of some Noctuids; but there is no difficulty in separating the two families, the Wood-nymph Moths being very different in appearance from any Noctuids.

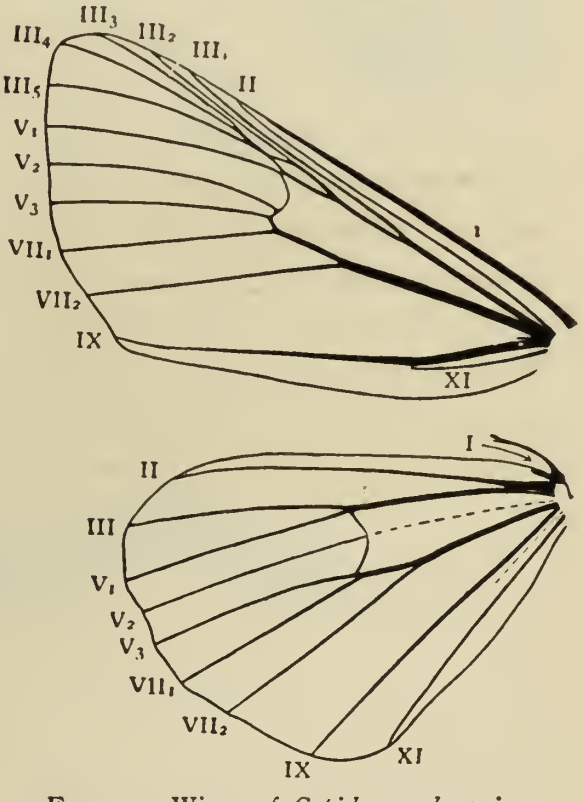


FIG. 379.—Wings of *Copidryas gloveri.*

The larvæ are but slightly clothed, and live exposed on the leaves of plants. Our more common species feed chiefly on grape and Virginia-creeper, which they sometimes injure to a serious extent. In such cases they can be destroyed by the use of Paris green. This substance can

be used even in vineyards in the East, as the application would have to be made early in the season, and the summer rains would wash the poison from the vines. The pupa state is passed either in an earthen cell or in a very slight cocoon.

The family is one of limited extent; less than thirty North American species are known. The larger number of these occur in the far West or in the Gulf States. The following are the most common species:—

The Eight-spotted Forester, *Alypia octomaculata* (A-lyp'-i-a oc-to-mac-u-la'ta).—This species is of a deep velvety-black color. The front wings have two large sulphur-yellow spots; and the hind wings, two white spots (Fig. 380). The figure represents a male; the female is somewhat larger. The patagia are sulphur-yellow. The legs are black with orange-colored scales on the tibiæ of the first and second pairs. The larva (Fig. 381) feeds upon the leaves of grape and Virginia-creeper, and sometimes occurs in such large numbers as to do serious injury. The ground-color of the larva is white, with eight black stripes on each segment, and a

FIG. 380.—*Alypia octomaculata.*

FIG. 381.—*Alypia octomaculata*, larva.

broader orange band, bounded by the two middle stripes; the orange bands are marked by black, conical, elevated spots. There are usually two broods each year, the moths appearing on the wing in May and August, the caterpillars in June and July, and in September. The pupa state is passed in an earthen cell in the ground.

Langton's Forester, *Alypia langtonii* (A. lang-to'ni-i), resembles the preceding species in general appearance, but

can be readily distinguished by the hind wings bearing only a single spot. It is not a common species, and its early stages have not yet been described.

The Grape-vine Epimenis, *Psychomorpha epimenis* (Psy-cho-mor'pha ep-i-me'nis).—This is a velvety-black species with a large white patch on the outer third of the front wings and a brick-red patch on the hind wings (Fig. 382). The larva resembles somewhat that of *Alypia* figured above; but it is bluish and has only four light and four dark stripes to each segment. It feeds upon the terminal shoots of grape and Virginia-creeper in spring, drawing the leaves together by a weak silken thread and destroying them. When ready to transform, which is usually towards the end of May, it either enters the ground or bores into soft wood to form a cell. Within this it remains until the following spring.

FIG. 382.—*Psychomorphv epimenis.*

The Beautiful Wood-nymph, *Euthisanotia grata* (Eu-this-a-no'ti-a gra'ta).—This moth (Fig. 383) well deserves the popular name that has been applied to it. Its front wings are creamy white, with a glassy surface; a wide brownish-purple stripe extends along the costal margin, reaching from the base to a little beyond the middle of the wing, and on the outer margin is a band of the same hue, which has a wavy white line running through it, and is margined internally with a narrow olive-green band. On the inner margin is a yellowish olive-green cloud. The hind wings are clear pale ochre-yellow, with a brown band on the outer margin. The wing expanse is about one and three-fourths inches. The moth appears during the latter part of June or early in July. The larva of this species is pale bluish, crossed by bands of orange and many fine black lines. It also bears a

FIG. 383.—*Euthisanotia grata.*

resemblance to that of *Alypia*, but may be distinguished by having only six transverse black lines on each segment. It has the same food-plants as the species described above. It transforms in a cell in the ground or in soft wood.

The Pearl Wood-nymph, *Euthisanotia unio* (E. u'ni-o).—This moth closely resembles the species just described, but is smaller, expanding a little less than one and one half inches. The outer border of the front wings is paler and mottled; and the band on the hind wings extends from the inner angle to the apex. The larva resembles that of *E. grata;* it feeds upon the leaves of *Euphorbia coloratum*, and perhaps on grape also.

Family PERICOPIDÆ (Per-i-cop'i-dæ).

The Pericopids (*Pe-ric'o-pids*).

These beautiful insects occur within the limits of our country only in the far West and in the Gulf States. They resemble the Wood-nymph Moths in their strongly contrasting colors; but can be distinguished from them by the position of the origin of vein V_2 of the hind wings, which appears to be a branch of cubitus (Fig. 384).

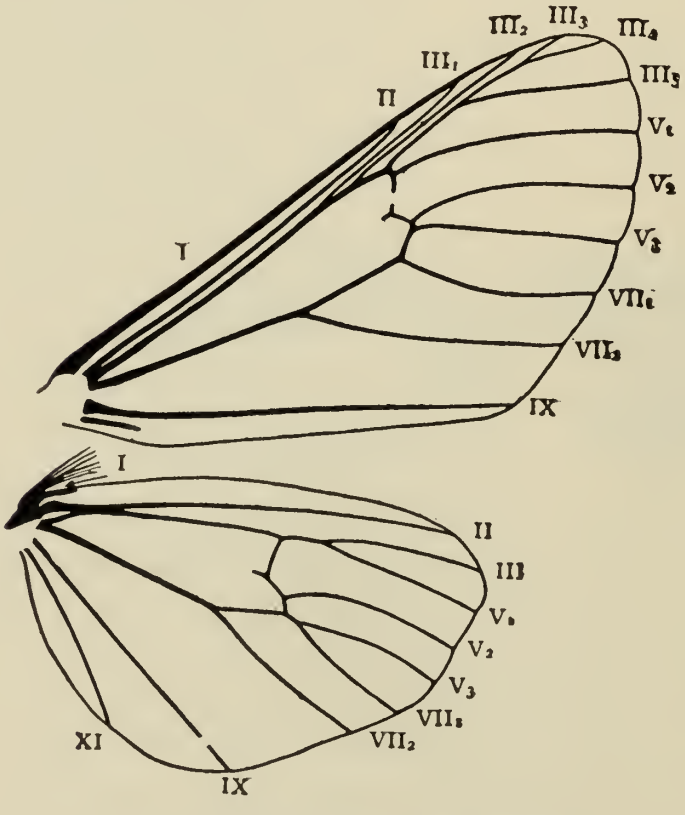


FIG. 384.—Wings of *Gnophæla hopfferi*.

Our most common species belong to the genus *Gnophæla* (Gnophæ'la). These are black with conspicuous yellow spots. *G. vermiculata*

(G. ver-mic-u-la'ta) occurs in Colorado; it is represented by Figure 385. *G. hopf-feri* (G. hopf'fe-ri) is found in California, in the foot-hills of the Sierra Nevadas. It has three yellow spots near the middle of the fore wing, and a transverse row of from three to five spots near the outer margin; on the hind wings there are two spots near the base and another pair between these and the apex of the wing.

FIG. 385.—*Gnophæla vermiculata.*

Family ARCTIIDÆ (Arc-ti'i-dæ).

The Tiger-moths, or Arctiids (Arc'ti-ids).

The Arctiidæ includes stout-bodied moths, with moderately broad wings, which in the majority of cases are conspicuously striped or spotted, suggesting the popular name Tiger-moths; some of the species, however, are unspotted. A large proportion of the species are exceedingly beautiful; this renders the family a favorite one with collectors. As a rule, when at rest, the wings are folded roof-like upon the body. The moths fly at night, and are attracted to lights.

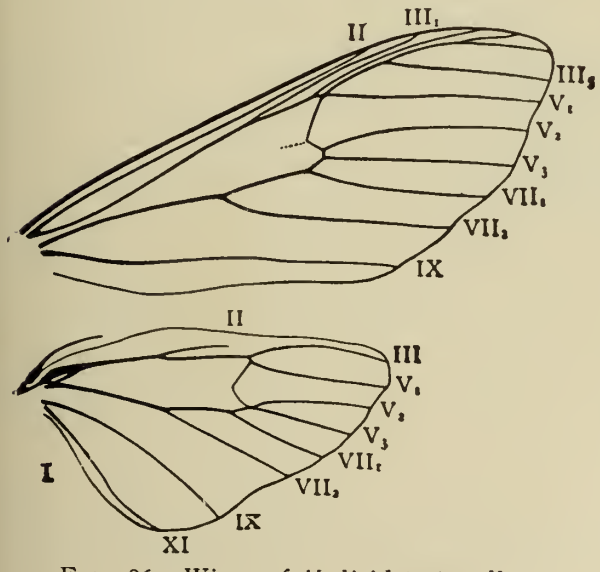


FIG. 386.—Wings of *Halisidota tessellata.*

These moths differ from the following family in having ocelli; these are often prominent, at other times they are difficult to see on account of the long hairs with which the head is

clothed. The palpi are short, usually but little developed; and the maxillæ are present. The most important features in the venation of the wings (Figs. 386, 387) is the union of veins V_2 and V_3 of the fore wings with cubitus, making it apparently four-branched; and the growing together of subcosta and radius of the hind wings for a considerable distance. The extent of the union of these two veins varies greatly in the different genera; but so far as we have observed it is always less than four fifths of the length of the discal cell. This character is of use in separating these insects from the Zygænidæ in which the union of these two veins is carried farther.

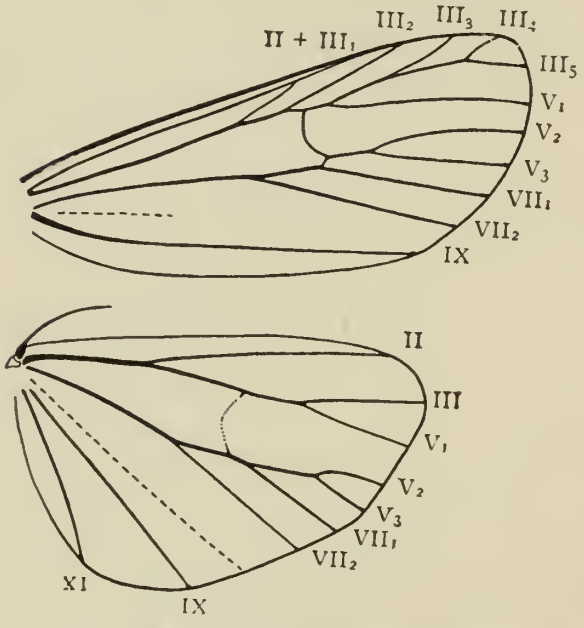


FIG. 387.—Wings of *Pygoctenucha funerea*.

The larvæ of the Tiger-moths are clothed with dense clusters of hairs. In fact a large proportion of our common hairy caterpillars are members of this family. In some species, certain of the clusters of hairs are much larger than the others, resembling in this respect the clothing of the Tussock-moths. Most larvæ of the Arctiids feed upon herbaceous plants, and many species seem to have but little choice of food-plant; but certain common species feed upon leaves of forest-trees.

About one hundred and fifty North American species have been described. The following are some of the more common representatives.

Among the more beautiful of the Tiger-moths is a genus the species of which are snow-white or light yellow with the

fore wings banded with dark brown. In most species the hind wings are unspotted and are snow-white, but in some the hind wings are yellow. These moths constitute the genus *Haploa* (Hap'lo-a). A species common in the Atlantic States and represented by Figure 388 is *Haploa contigua* (H. con-tig'u-a). The insects of this genus vary greatly in their markings.

FIG. 388.—*Haploa contigua.*

The Bella-moth, *Utetheisa bella* (U-te-thei'sa bel'la) is a whitish moth with lemon-yellow or orange-colored fore wings, crossed by six transverse white bands, each containing a series of black dots (Fig. 389); the hind wings are pink, with a black outer margin, which is bordered within by a narrow white line. The species occurs throughout the Atlantic States.

FIG. 389.—*Utetheisa bella.*

The Harlequin Milkweed Caterpillar, *Cycnia egle* (Cyc'ni-a eg'le).—This larva is the most common caterpillar found on milkweed. It is clothed with tufts of orange, black, and white; those at each end of the body are longer than the others, and are arranged radiately (Fig. 390). When full grown

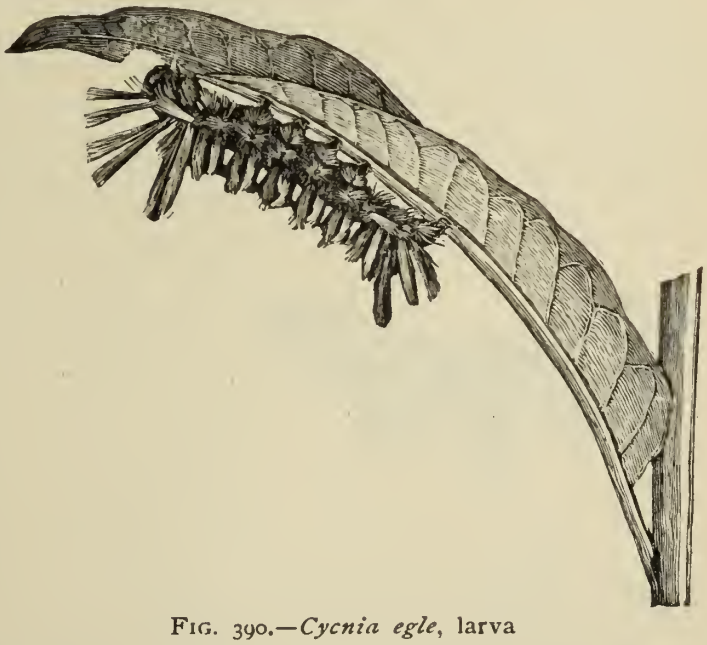


FIG. 390.—*Cycnia egle*, larva

the larva makes a felt-like cocoon composed largely of its hairs. The adult has mouse-gray, unspotted wings; the abdomen is yellow, with a row of black spots along the middle of the back.

The Hickory Tiger-moth, *Halisidota caryæ* (Ha-lis-i-do'ta ca'ry-æ).—One of the most abundant of caterpillars in the Atlantic States and westward during the months of August and September is one clothed with dense tufts of finely barbed white hairs (Fig. 391); there is a ridge or crest

FIG. 391.—*Halisidota caryæ*, larva.

of black hairs on the middle of the back of the abdominal segments, a few long white hairs projecting over the head from the thorax, and others projecting back from the last segment; there are also two pairs of pencils of black hairs, one on the first and one on the seventh abdominal segment, and a similar pair of pencils of white hairs on the eighth abdominal segment. This larva feeds on hickory, butternut, and other forest-trees. Its grayish cocoons, composed almost entirely of the hair of the larva, are often found under stones, fences, and other similar places. The fore wings of the adult (Fig. 392) are dark brown spotted with white.

FIG. 392.—*Halisidota caryæ*.

The Salt-marsh Caterpillar, *Estigmene acræa* (Es-tig-me'ne a-cræ'a).—The popular name of this insect was given to it by Harris, and was suggested by the fact that the salt-marsh meadows about Boston were overrun and laid waste in his time by swarms of the larvæ. But the name is misleading, as the species is widely distributed throughout the United States. The moth (Fig. 393) is white, marked with yellow and black. There are many black dots on the wings, a row of black spots on the back of the abdomen, another row on the venter, and two rows on each side. The sexes differ greatly in the ground-color of the wings; in the female, this is white throughout; in the male, only the upper surface of the fore wings is white, the lower surface of the fore wings and the hind wings above and below being yellow. The number and size of the black spots on the wings vary greatly. There are usually more submarginal spots on the hind wings than represented in our figure.

FIG. 393.—*Estigmene acræa.*

The Fall Web-worm, *Hyphantria cunea* (Hy-phan'tri-a cu'ne-a).—A very common sight in autumn in all parts of our country is large ugly webs enclosing branches of fruit or forest trees. These webs are especially common on apple and on ash. Each web is the residence of a colony of larvæ which have hatched from a cluster of eggs, laid on a leaf by a snow-white moth. There is a variety of this moth in which the fore wings are thickly studded with dark brown spots. Every gradation exists between this form and those that are spotless. The species winters in the pupa state, and the moths emerge during May or June. The webs made by this insect should not be confounded with those made by the Apple-tree Tent-caterpillar. The webs of the Fall Web-worm are made in the autumn, and

are much lighter in texture, being extended over all of the leaves fed upon by the colony.

The Isabella Tiger-moth, *Pyrrharctia isabella* (Pyr-rharc'-ti-a is-a-bel'la).—"Hurrying along like a caterpillar in the fall" is a common saying among country people in New England, and probably had its origin in observations made upon the larva of the Isabella Tiger-moth. This is the evenly clipped, furry caterpillar, reddish brown in the middle and black at either end, which is seen so commonly in the autumn and early spring (Fig. 394). Its evident haste to get somewhere, in the autumn, is almost painful to witness. A nervous anxiety is apparent in every undulating movement of its body; and frequently its shining black head is raised high in the air, and moved from side to side, while it gets its bearings. Occasionally after such an observation it evidently finds it is mistaken, and turns sharply and hastens along faster than ever in another direction. So far as we can judge, its excitement comes from a sudden fear that winter will overtake it before it can find a cosy, protected corner in which to pass its winter sleep. In the spring it comes forth again, and after feeding for a time makes a blackish-brown cocoon composed largely of its hair. The adult is of a dull grayish tawny-yellow, with a few black dots on the wings, and frequently with the hinder pair tinged with orange-red. On the middle of the back of the abdomen there is a row of about six black dots, and on each side of the body a similar row of dots.

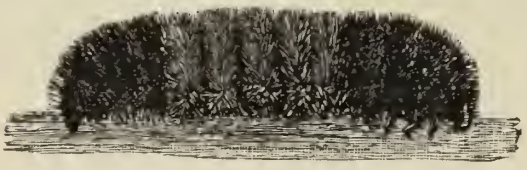


FIG. 394.—*Pyrrharctia isabella*, larva.

The Yellow-bear, *Spilosoma virginica* (Spil-o-so'ma virgin'i-ca).—The larva of this species is one of the most common hairy caterpillars found feeding on herbaceous plants. It was named by Harris the Yellow-bear on account of the long yellow hairs with which the body is clothed. These hairs are uneven in length, some scattered ones being twice

as long as the greater number of hairs. The long hairs are more numerous near the caudal end than elsewhere, but are nowhere gathered into pencils as with the Tussock-caterpillars. This larva varies greatly in color. The body is most often of a pale yellow or straw color, with a black, more or less interrupted, longitudinal line along each side, and a more or less distinct transverse line of the same color between each of the segments. Sometimes the hairs are foxy red or light brown, and the body brownish or even dark brown. The head and the ends of the feet and forelegs are yellowish, and the venter is dusky. The larva feeds on almost any plant. The cocoon is light, and is composed almost entirely of the hairs of the caterpillar. This insect passes the winter in the pupa state; and it is probable that there are usually two or more broods each year; but these are not well marked. The moth (Fig. 395) is snowy white, with the wings marked by a few black dots; these vary in number, but there are rarely more than three on either wing. There is a row of black spots on the back of the abdomen, and another on each side, and between these a longitudinal deep yellow stripe.

FIG. 395.—*Spilosoma virginica.*

A very large number of species of Tiger-moths belong to the genus *Eyprepia* (Ey-pre′pi-a). These are perhaps the most striking in appearance of all members of the family. The fore wings are velvety black marked with yellowish or pink bands; in some species the lighter color predominates, so that the fore wings appear to be yellow or pink, spotted

FIG. 396.—*Eyprepia virgo.*

with black. The hind wings are red, pink, or yellow, and are margined or spotted with black. The thorax is usually marked with three black stripes, of which the lateral ones are borne by the patagia. There is also a black line or a row of black spots along the middle of the back of the abdomen, and a similar row of spots on each side. Our most common species of this genus is *Eyprepia virgo* (Fig. 396). The larva of this species feeds on pigweed and other uncultivated plants.

Family LITHOSIIDÆ (Lith-o-si'i-dæ).

The Footman-moths or Lithosiids (*Li-tho'si-ids*).

The Lithosiidæ include small moths with rather slender bodies, filiform antennæ, and usually narrow front wings and broad hind wings. As a rule they are closely scaled insects of sombre colors, a fact that has won for them the title of Footman-moths; but in case of some of the species their livery is very gay. Some species fly by day, while others are attracted to lights at night.

This family is closely allied to the Arctiidæ; in fact it is sometimes difficult to tell to which of these families a species belongs. Usually the Footman-moths can be distinguished by the absence of ocelli; but some species possess very small ones. The palpi are small or moderately developed; the maxillæ are present and quite well developed. The venation of the wings differs greatly in the different genera; but in its more important features it resembles that of the Arctiidæ.

The larvæ are cylindrical and covered with short, stiff hairs. The majority of the species whose transformations are known feed upon lichens. They transform in very delicate cocoons or have naked pupæ. Among our more common species are the following:—

The Pale Footman, *Crambidia pallida* (Cram-bid'i-a pal'-li-da.—This moth is of a uniform drab color, with the abdomen and the inner part of hind wings paler; it expands nine

tenths of an inch. The moths of the genus *Crambidia* can be recognized by the fact that veins V_2 and V_3 of the fore wings are both wanting, leaving cubitus only two-branched.

The Two-colored Footman, *Lithosia bicolor* (Li-tho'si-a bi'co-lor).—This is larger than the preceding species, expanding from one to one and one half inches. It is slate-colored, with the palpi, the prothorax, the costa of the fore wings, and the tip of the abdomen yellow. Vein V_2 of the fore wings is wanting, leaving cubitus apparently three-branched

The Striped Footman, *Hypoprepia miniata* (Hy-po-pre' pi-a min-i-a'ta).—This beautiful moth is of a deep scarlet color, with three broad lead-colored stripes on the front wings. Two of the stripes extend the entire length of the wings; while the third is between these and extends from the end of the discal cell to the outer margin (Fig. 397). The outer half of the hind wings is also slate-colored. Vein V_2 of the fore wings is present; but vein V_2 of the hind wings is wanting. The larva feeds upon lichens, and may be found under loose stones or on the trunks of trees. It is dusky, and thinly covered with stiff, sharp, and barbed black bristles, which grow singly from small warts. The cocoon is thin and silky.

FIG. 397.—*Hypoprepia miniata.*

The Painted Footman, *Hypoprepia fucosa* (Hy-po-pre'pi-a fu-co'sa).—This species is very similar to the preceding and has been confounded with it. With the Painted Footman the ground-color of the fore wings is partly yellow and partly red.

The Clothed-in-white Footman, *Clemensia albata* (Clemen'si-a al-ba'ta).—The specific name of this insect is somewhat misleading; for although the general color of the moth is white, there are so many ashen and gray scales, and dark spots, that the general effect is gray. On the front wings the more prominent black spots are six or seven on the costa, one on the discal vein, and a row of small ones on the

outer margin. The hind wings are white, but finely dusted with gray scales. With this species vein V_2 is present in both fore and hind wings.

The Banded Footman, *Cisthene unifascia* (Cis-the'ne u-ni-fas'ci-a).—This little beauty (Fig. 398) occurs in the Atlantic States from New York to Texas. The fore wings are lead-colored, and crossed by a yellow band, which extends also along the inner margin to the base of the wings. The hind wings are pink except the apex, which is lead-colored. There is much variation in the width of the yellow band.

FIG. 398.—*Cisthene unifascia.*

Family ZYGÆNIDÆ (Zy-gæn'i-dæ).

The Zygænids (*Zy-gæ'nids*).

These moths are most easily distinguished from the allied families that are represented in this country by the structure of the hind wings. Here we find the tendency of veins II and III to coalesce carried to the greatest extreme, they being joined clear to the margin of the wing (Fig. 399); occasionally forms are found in which the tips of these two veins are separate for a short distance near the apex of the wing; and usually they are separated for a short distance near the base of the wing, as shown in the figure. In some of the more

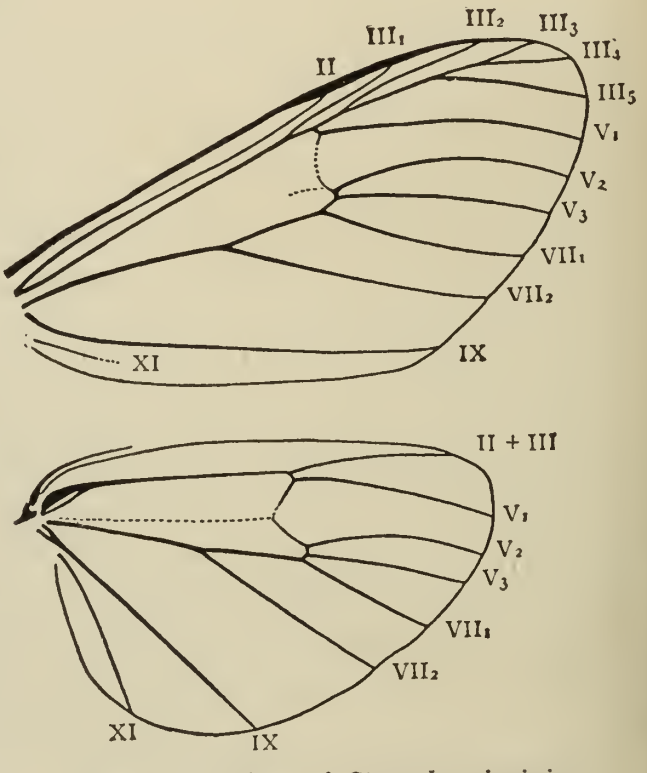


FIG. 399.—Wings of *Ctenucha virginica.*

specialized forms, as *Cosmosoma* (Fig. 400), the hind wings are greatly reduced in size, and the branches of radius and cubitus coalesce to a remarkable degree.

FIG. 400.—*Cosmosoma auge.*

To the first division of this family belong a small number of bluish-black or brown moths which have more or less vermilion or yellow on the head, prothorax, and patagia. These moths are of medium size, expanding from one and one fifth to two inches. The dull color of the wings is usually relieved by the bright color of the head and patagia, and by a layer of blue scales covering the thorax and abdomen; but in some species these are wanting. The larvæ feed on grasses. Some of them strongly resemble those of the Arctiidæ in appearance as well as in habits, being thickly clothed with hair; they also spin cocoons similar to those of Arctiids. Our common forms represent two

FIG. 401.—*Ctenucha virginica.*

FIG. 402.—*Scepsis fulvicollis.*

genera, *Ctenucha* (Cte-nu'cha) and *Scepsis* (Scep'sis). In the East we have only a single species of each of these genera, *Ctenucha virginica* (C. vir-gin'i-ca), which is represented by Figure 401, and *Scepsis fulvicollis* (S. ful-vi-col'lis), represented by Figure 402.

FIG. 403.—*Lycomorpha pholus.*

The second division of the family includes a much larger number and a much greater variety of forms. Our most common species is *Lycomorpha pholus* (Ly-co-mor'pha pho'lus). This is black with the basal half of the fore wings and the basal third of the hind

wings yellow (Fig. 403). A variety of this species occurs in California in which the lighter parts of the wings are pinkish instead of yellow. These moths occur in stony places, where the larvæ feed on lichens growing on rocks.

In the extreme southern part of our country and in the regions south of that, there occur highly specialized members of this family, in which the hind wings are greatly reduced in size, and the veins of the hind wings coalesce to a remarkable degree. In some of these forms the discal portion of the wings bears but few if any scales. *Cosmosoma auge* (Cos-mo-so'ma au'ge) from Florida (Fig. 400) will serve as an example of these. In this species the body and legs are bright red, with the head, end of abdomen, and a dorsal band blue-black; the veins and borders of the wings are also black.

Family THYRIDIDÆ (Thy-rid'i-dæ).

The Window-winged Moths.

These little moths can be easily recognized by the presence of curious white or yellowish translucent spots upon the wings; it is these spots that suggests the name Window-winged Moths for the family.

In this family the antennæ are either strictly filiform or slightly thickened in the middle; the ocelli are wanting; the palpi project horizontally, and are somewhat longer than the head; and the maxillæ are strongly developed. The venation of the wings differs from that of all other families of moths, in that all five branches of radius of the fore wings are preserved and arise from the discal cell (Fig. 404).* A similar type of venation is

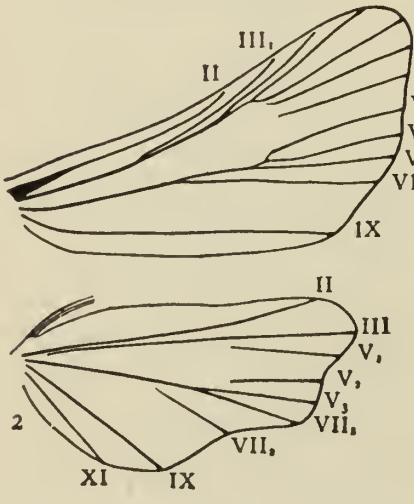


FIG. 404.—Wings of *Thyris maculata.*

* In a single genus of the Pyromorphidæ, *Triprocris* (p. 227, Fig. 268), all the branches of radius arise from the discal cell.

possessed by the Skippers (Hesperina); but the Window-winged Moths differ from the Skippers in having a well-developed frenulum.

The early stages of our species are not known; but the larva of a European species lives upon the leaves of Clematis, which it rolls like a Tortricid. This larva is said to appear like that of a Chrysomelid beetle. It descends to the surface of the ground and makes a dense silken cocoon, more or less mixed with grains of sand.

The most common representative of this family in the Eastern and Middle States is the Spotted Thyris, *Thyris maculata* (Thy'ris mac-u-la'ta). This species (Fig. 405) is brownish black, sprinkled with rust-yellow dots; the outer margin of the wings, especially of the hind wings, is deeply scalloped, with the edges of the indentations white. There is on each wing a translucent white spot; that of the hind wing is larger, kidney-shaped, and almost divided in two. This species occurs also in the West, as there are specimens from Montana in the Cornell University collection.

FIG. 405.—*Thyris maculata.*

The Mournful Thyris, *Thyris lugubris* (Thy'ris lu-gu'bris), is a larger species found in the Southern States. It can be recognized by Figure 406. It is brownish black, marked with yellow, and with the translucent spots yellowish.

FIG. 406.—*Thyris lugubris.*

Family SPHINGIDÆ (Sphin'gi-dæ).

The Hawk-moths or Sphinxes.

Hawk-moths are easily recognized by the form of the body, wings, and antennæ. The body is very stout and spindle-shaped; the wings are long, narrow, and very strong; the antennæ are more or less thickened in the middle or towards the tip, which is frequently curved back in the form of a hook; rarely the antennæ are pectinated. The sucking-tube (maxillæ) is usually very long, being in some instances twice

as long as the body; but in one subfamily it is short and membranous. When not in use it is closely coiled like a watch-spring beneath the head. None of the species have ocelli.

The venation of the wings (Fig. 407) is quite characteristic; the most distinctive feature is the presence of what

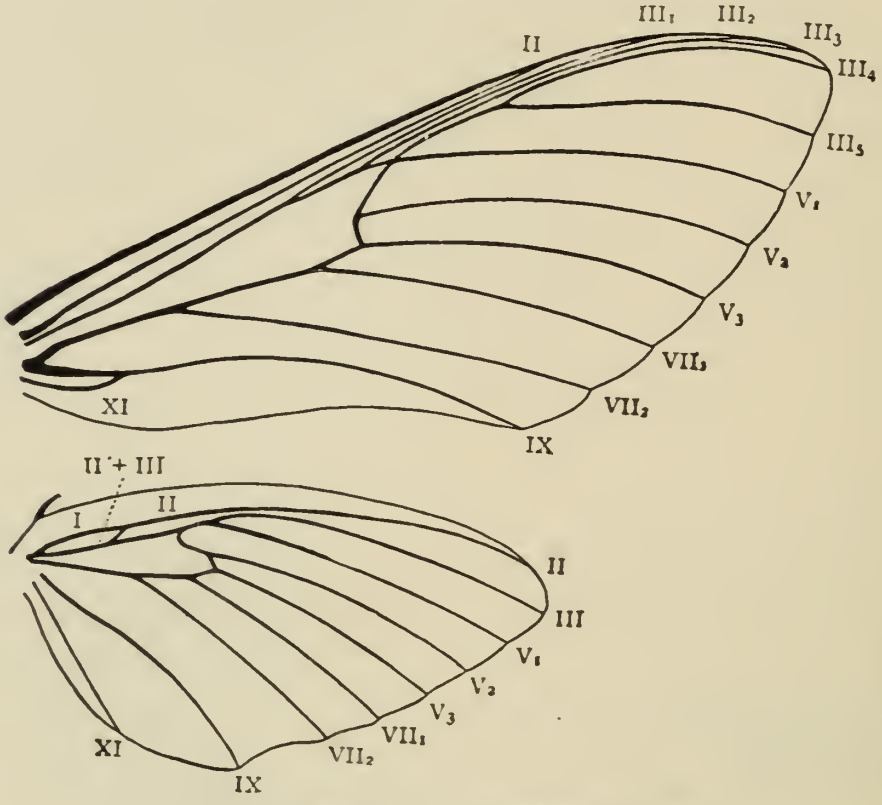


FIG. 407.—Wings of *Phlegethontius celeus*.

appears to be a cross-vein between subcosta and radius of the hind wing. This apparent cross-vein is due to the fact that veins II and III are grown together for a short distance, and then vein II separates and joins vein I. The obvious presence of vein I in the hind wings is unusual; but it occurs in the Psychidæ, in the Bombycidæ, and in the Anthroceridæ (a family not represented in our fauna) also. This basal part of vein I is probably preserved in other cases where it appears to be the base of vein II. Thus in *Citheronia* (Fig. 417) there is a rudiment of the so-called cross-vein, which has entirely disappeared in the more specialized forms of the family to

which this genus belongs. In the Hawk-moths the frenulum is usually well preserved, but in a few it is wanting or rudimentary. In many genera vein III_2 of the fore wings coalesces with vein III_3 to its tip, so that vein III is only four-branched.

Some of the Hawk-moths are small or of medium size; but most of them are large. They have the most powerful wings of all Lepidoptera. As a rule they fly in the twilight, and have the habit of remaining poised over a flower while extracting the nectar, holding themselves in this position by a rapid motion of the wings. This attitude and the whir of the vibrating wings gives them a strong resemblance to humming-birds, hence they are sometimes called Humming-bird Moths; but they are more often called Hawk-moths, on account of their long, narrow wings and strong flight.

Of all the beautifully arrayed Lepidoptera some of the Hawk-moths are the most truly elegant. There is a high-bred tailor-made air about their clear-cut wings, their closely fitted scales, and their quiet but exquisite colors. The harmony of the combined hues of olive and tan, ochre and brown, black and yellow, and grays of every conceivable shade, with touches here and there of rose color, is a perpetual joy to the artistic eye. They seldom have vivid colors except touches of yellow or pink on the abdomen or hind wings, as if their fastidious taste allowed petticoats only of brilliant colors always to be worn beneath quiet-toned overdresses.

The larvæ of the Sphingidæ feed upon leaves of various plants and trees, and are often large and quite remarkable in appearance (Fig. 408). The body is cylindrical and naked and usually has a horn behind near the end of the body on the eighth abdominal segment. Sometimes instead of the horn there is a shiny tubercle or knob. We cannot even guess the use of this horn, unless it is ornamental, for it is never provided with a sting. These caterpillars when resting rear the front of the body up in the air, curl the head down in the most majestic manner, and remain thus

rigid and motionless for hours. When in this attitude they are supposed to resemble the Egyptian Sphinx, and so the typical genus was named Sphinx and the family the Sphingidæ. But we think they deserve the name independently of their habits because of the riddle they constantly propound to us as to why they wear this horn on the rear end of the body instead of on the head, where it ought to be in order to be of

FIG. 408.—*Sphinx chersis*, larva.

any use whatever as a horn. These caterpillars are usually of some shade of green and often are ornamented with a series of diagonal stripes along each side.

Most species pass the pupa state in the ground in simple cells made in the earth ; some, however, transform on the surface of the ground in imperfect cocoons composed of leaves fastened together with silk.

Nearly one hundred species of Hawk-moths occur in this country. The following are some of the more common ones.

The Modest Sphinx, *Marumba modesta* (Ma-rum'ba mo-des'ta).—It was, probably, the quiet olive tints in which the moth is chiefly clothed that suggested the name *modesta* for it, but it is one of the most beautiful of our Hawk-moths. The body and basal third of the fore wings are pale olive; the outer third of the fore wings is a darker shade of the same color; while the middle third is still darker (Fig. 409).

FIG. 409.—*Marumba modesta.*

The hind wings are dull carmine-red in the middle; there is a bluish-gray patch with a curved black streak over it near the anal angle. The larva feeds on poplar and cotton-wood. When full grown it is three inches long, of a pale green color, and coarsely granulated, the granules studded with fine white points, giving the skin a frosted appearance.

The Twin-spotted Sphinx, *Smerinthus geminatus* (Sme-rin'thus gem-i-na'-tus).—This exquis-itely colored moth expands about two and one half inches. The thorax is gray with a velvety dark brown spot in the middle. The fore wings are gray, with a faint rosy tint in some specimens,

FIG. 410.—*Smerinthus geminatus.*

and tipped and banded with brown as shown in Figure 410. The hind wings are deep carmine at the middle, and are bordered with pale tan or gray. Near the anal angle there is a large black spot in which there is a pair of blue spots, which suggested the name *geminatus*. The larva feeds upon the leaves of apple, plum, elm, ash, and willow.

Harris's Sphinx, *Ellema harrisii* (El-le'ma har-ris'i-i).—This sphinx has interested us chiefly on account of the habits and markings of its larva (Fig. 411). It feeds upon the foliage of pine, and is colored with alternating green and white longitudinal strips; the dorsal stripe is green spotted with red. It has a way of hanging head downward in a pine tassel that conceals it entirely from the sight of all but very sharp eyes, its stripes giving a close resemblance to a bunch of pine leaves. The moth expands about two inches; it is gray with the fore wings marked by several series of small brown spots.

FIG. 411.—*Ellema harrisii*, larva.

The Pen marked Sphinx, *Sphinx chersis* (Sphinx cher'sis).—This moth is of an almost evenly distributed ashy-gray color. This sombre color is relieved somewhat by a black band on each side of the abdomen, marked with four or five white transverse bars; by two dark brown, smoky bands which cross the hind wings; and by a series of black dashes on the fore wings, one in each cell between the apex of the wing and the anal vein. These dashes appear as if drawn casually with a pen. The larva (Fig. 408) is not uncommon upon ash and lilac; it is greenish or bluish white above, and darker below; there are seven oblique yellow bands on the sides of the body, each edged

above with dark green. When disturbed it assumes the threatening attitude shown in the figure.

The Tomato-worm, *Phlegethontius celeus* (Phleg-e-thon′-ti-us ce′le-us). — This larva is the best known of all our Sphinxes, as it may be found feeding on the leaves of tomato, tobacco, or potato wherever these plants are grown in our country. It resembles in its general appearance the larva of *Sphinx chersis* (Fig. 408); but its favorite attitude is with the fore end of the body slightly raised. It is usually green, but individuals are often found that are brown, or even black. There appear at frequent intervals in the newspapers accounts of people being injured by a poison excreted by the caudal horn of this larva; but there is absolutely no foundation whatever for such stories. The pupa (Fig. 412) is often ploughed up in gardens, and attracts attention on account of its curious tongue-case, which is free, resembling the handle of a pitcher. The moth is a superb creature, expanding four or five inches. It is of many delicate shades of ash-gray, marked with black or very dark gray; there are a few short black dashes on the fore part of the thorax, and some irregular black spots edged with white on the posterior part; the abdomen is gray with a black middle line, and five yellow, almost square spots along each side. Each of these spots is bordered with black, and has a white spot above and below, on the edge of the segment. The hind wings are crossed by four blackish lines, of which the two intermediate are zigzag.

FIG. 412.—*Phlegethontius celeus.*

The Tobacco-worm, *Phlegethontius carolina* (Phleg-e-thon′-ti-us car-o-li′na).—This species closely resembles the preceding, and the two are often mistaken the one for the other. The larvæ have similar habits, feeding on the same plants. But the moths are easily distinguished. This species is brown-

ish gray instead of ashy gray; at the end of the discal cell of the fore wings there is a distinct white spot; and the two dark bands crossing the middle of the hind wings are not zigzag, and are less distinctly separate; often they are united into a single broad band.

The Hog-caterpillar of the Vine, *Ampelophaga myron* (Am-pe-loph'a-ga my'ron).—There is a group of Hawk-moths the larvæ of which have the head and first two thoracic segments small, while the two following segments are greatly swollen. These larvæ from a fancied resemblance to fat swine have been termed Hog-caterpillars; and the present species, which is common on grape, has been named the Hog-caterpillar of the Vine. It is a comparatively small species, the full-grown larva being but little more than two inches long. There is a row of seven spots varying in color from red to pale lilac, each set in a patch of pale yellow, along the middle of the back. A white stripe with dark green margins extends along the side from the head to the caudal horn, and below this are seven oblique stripes. This larva is often infested by Braconid parasites; and it is a common occurrence to find one of them with the cocoons of the parasites attached to it (Fig. 413). The pupa state is passed on the surface of the ground within a rude cocoon made by fastening leaves together with loose silken threads. The adult expands about two and one fourth inches. The fore wings are olive-gray, with a curved, olive-green, oblique band crossing the basal third, a discal point of the same color, and beyond this a large triangular spot with its apex on the costa and its base on the inner margin.

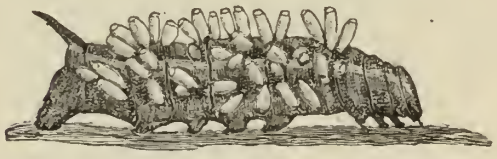


FIG. 413.—*Ampelophaga myron*, larva with cocoons of parasites.

The Pandorus Sphinx, *Philampelus pandorus* (Phi-lam'pe-lus pan-do'rus).—This magnificent moth expands from four to four and one half inches. The ground-color of its wings

is pale olive, verging in some places into gray; the markings consist of patches and stripes of dark, rich velvety olive, sometimes almost black (Fig. 414). Near the inner margins of both pairs of wings the lighter color shades out into pale yellow, which is tinged in places with delicate rose-color.

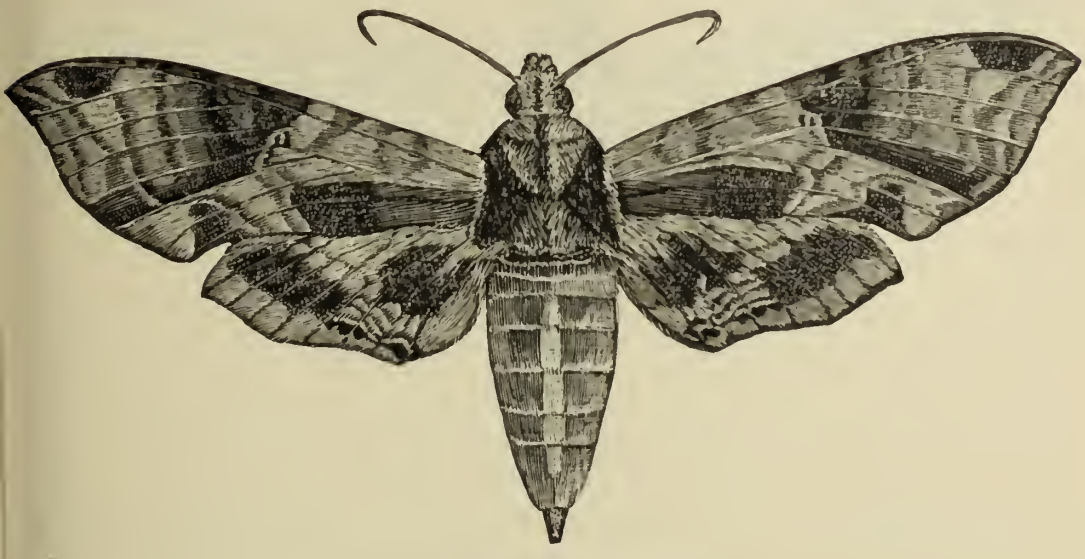


FIG. 414.—*Philampelus pandorus.*

These markings show a harmony of contrasting shades rarely equalled elsewhere by nature or art. The larva is one of the Hog-caterpillars. It feeds upon the leaves of Virginia-creeper. When young it is pinkish in color, and has a long pinkish caudal horn; as it matures it changes to a reddish brown, and the horn shortens and curls up like a dog's tail and finally disappears, leaving an eye-like tubercle. The caterpillar has on each side six cream-colored oval spots, enveloping the spiracles.

The White-lined Sphinx, *Deilephila lineata* (Dei-leph'i-la lin-e-a'ta).—This moth can be easily recognized by Figure 415. Its body and fore wings are olive-brown; there are three parallel white stripes along each side of the thorax; the outer one of these extends forward over the eyes to the base of the palpi; on the fore wings there is a buff stripe extending from near the base of the inner margin to the apex, and veins III_5 to IX are lined with white; the hind

wings are black with a central reddish band. The larva is extremely variable in color and markings. It feeds on many plants, among which are apple, grape, plum, and currant.

FIG. 415.—*Deilephila lineata.*

The Thysbe Clear-wing, *Hemaris thysbe* (He-ma'ris thys'be).—There is a group of Hawk-moths that have the middle portion of the wings transparent, resembling in this respect the Sesiidæ and certain Zygænids; but they are easily recognized as Hawk-moths by the form of the body, wings, and antennæ. One of the more common of these is the Thysbe Clear-wing (Fig. 416). The scaled portions of the wings are of a dark reddish brown; but this species is most easily distinguished from our other common species by a line of scales dividing the discal cell lengthwise and representing the position of the base of vein V. The larva of this species feeds on the different species of *Viburnum*, the snowberry, and hawthorn.

FIG. 416.—*Hemaris thysbe.*

The Bumblebee Hawk-moth, *Hemaris diffinis* (He-ma'ris dif-fi'nis).—This Clear-wing appears to be about as common

as the preceding, and resembles it somewhat. It lacks, however, the line of scales in the discal cell, and the body is more nearly yellow. This color probably suggested the name Bumblebee Hawk-moth, given to this insect nearly one hundred years ago by Smith and Abbot. The larva feeds on the bush honeysuckle (*Diervilla*) and the snowberry (*Symphoricarpus*).

Superfamily SATURNIINA (Sa-tur-ni-i'na).

The Saturnians (*Sa-tur'ni-ans*).

The group of families constituting the superfamily Saturniina includes the largest of our native moths; in fact nearly all of our very large moths belong to it; but it also includes a considerable number of species of moderate size.

These moths are most easily distinguished from other moths by the structure of the wings (Fig. 417). Here, as with the Skippers and the Butterflies, the frenulum is lost (or nearly so in the lowest family), and its place is taken by a greatly expanded humeral angle of the hind wing, which, projecting under the fore wing, insures the acting together of the two in flight without the aid of a frenulum. This losing of the frenulum is also characteristic of the Lasiocampidæ. But the Saturnians differ from this family in that vein V_2 arises midway between radius and cubitus, or is

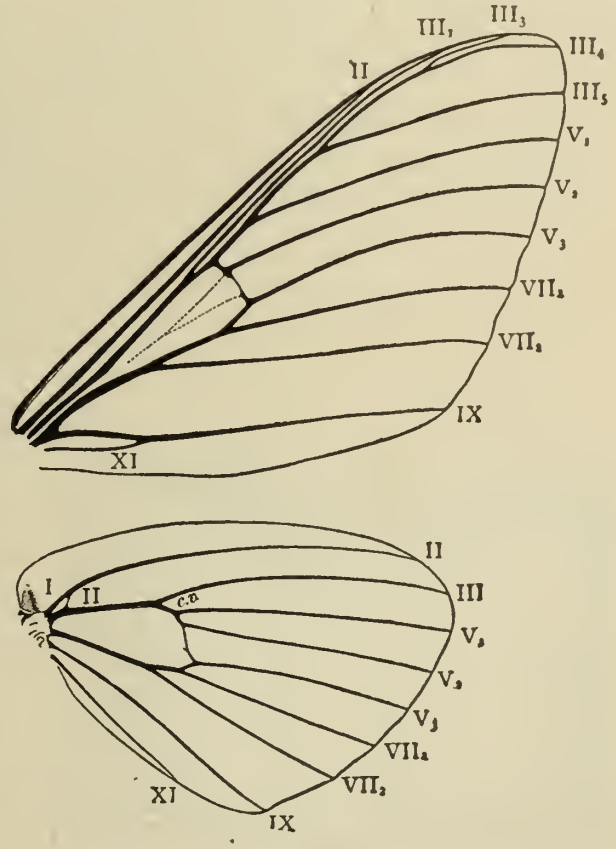


FIG. 417.—Wings of *Citheronia regalis*.

more closely united to radius than to cubitus, leaving the latter apparently three-branched; while in the Lasiocampidæ cubitus appears to be four-branched.

This superfamily includes the Bombycidæ which are represented in this country only by the Chinese Silkworm and three families of native moths. These can be separated by the following table :—

A. Vein V_2 of the fore wings arising midway between veins V_1 and V_3. p. 340 ..... BOMBYCIDÆ.

AA. Vein V_2 of the fore wings arising nearer to vein V_1 than to vein V_3.

B. Hind wings with two anal veins.

C. The stalk of veins V_1 and V_2 of the *fore* wings separating from radius before the end of the discal cell (Fig. 420, *c. v.*). p. 342 ..... HEMILEUCIDÆ.

CC. Vein V_1 of the *fore* wings separating from radius beyond the apex of the discal cell.

D. Veins V_1 and V_2 of the *hind* wings joined to radius by a distinct stalk (Fig. 417, *c. v.*). p. 343..... CITHERONIIDÆ.

DD. Vein V_1 and V_2 of the hind wings not stalked (*Coloradia*). p. 350..... SATURNIIDÆ.

BB. Hind wings with only one anal vein. p. 350... SATURNIIDÆ.

Family BOMBYCIDÆ (Bom-byc'i-dæ).

The Silk-worm.

The Bombycidæ as now restricted are not represented in our fauna; but a single species, the Silk-worm, is frequently bred in this country, and is usually present in collections of Lepidoptera.

FIG. 418.—*Bombyx mori.*

The Silk-worm, *Bombyx mori* (Bom'byx mo'ri).—The moth (Fig. 418) is of a cream-color with two or three more or less distinct brownish lines across the fore

wings and sometimes a faint double bar at the end of the discal cell. The head is small; the antennæ are pectinated broadly in both sexes; and the ocelli, palpi, and maxillæ are wanting. The abdomen and thorax are densely clothed with woolly hair. The distinctive feature in the venation of the wings (Fig. 419) is the obvious presence of vein I on the hind wings.

The usual food of the Silk-worm is the leaf of the mulberry. Our native species, however, are not suitable. The species that are most used are the white mulberry (*Morus alba*), of which there are several varieties, and the black mulberry (*Morus nigra*); the former is the better. The leaves of osage orange (*Maclura aurantiaca*) have also been used as silk-worm food to a considerable extent. In case silk-worms hatch in the spring before either mulberry or osage-orange leaves can be obtained, they may be quite successfully fed, for a few days, upon lettuce-leaves.

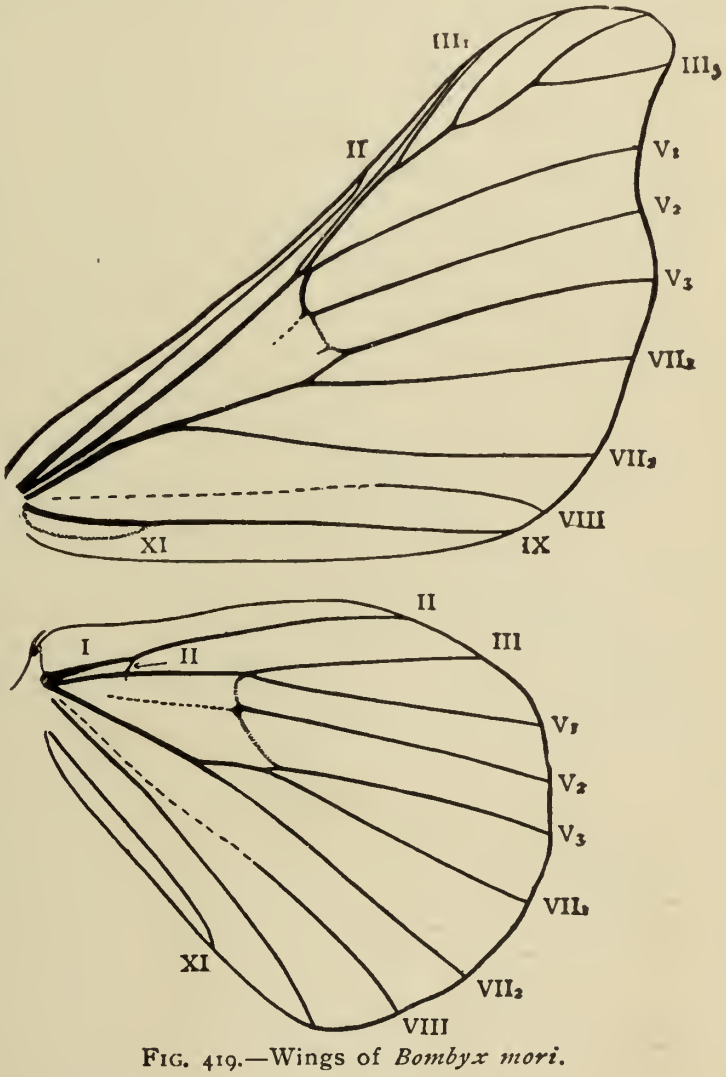


FIG. 419.—Wings of *Bombyx mori*.

The newly-hatched larva is black or dark gray, and is covered with long stiff hairs, which spring from pale-colored tubercles. The hairs and tubercles are not noticeable after

the first molt, and the worm becomes lighter and lighter, until in the last larval period it is of a cream-white color. There is a prominent tubercle on the back of the eighth abdominal segment, resembling those borne by certain larvæ of the Sphingidæ.

There are many special treatises on this insect, some of which should be consulted by any one intending to raise silkworms.

Family HEMILEUCIDÆ (Hem-i-leu'ci-dæ).

The Hemileucids (*Hem-i-leu'cids*).

This is a small family containing rather large and conspicuously marked insects. The antennæ are broadly pectinated in the males and narrowly so or nearly serrate in the females. There is only a single pair of teeth to each segment of the antennæ. The thorax and abdomen are usually thickly clothed with long woolly hair; but in some species the clothing of the antennæ is less woolly and more scale-like. As to the wings, the frenulum is wanting, the humeral angle of the hind wings being largely developed (Fig. 420); and in both fore and hind wings veins V_1 and V_2 are joined to radius by a common stalk.

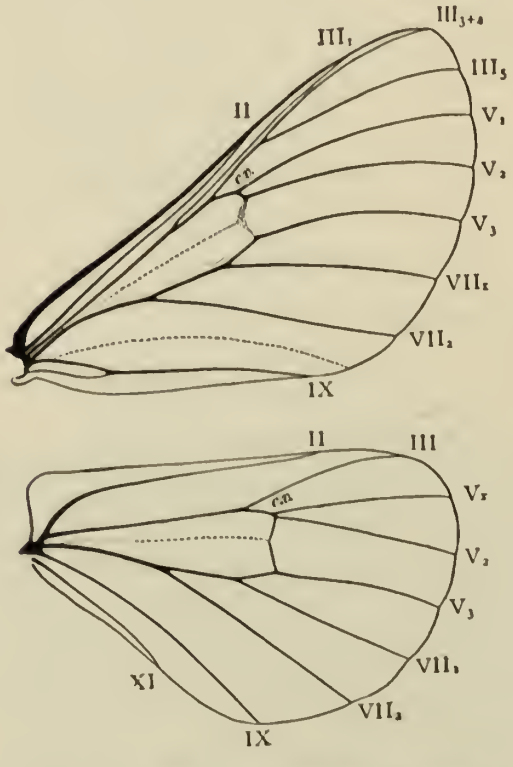
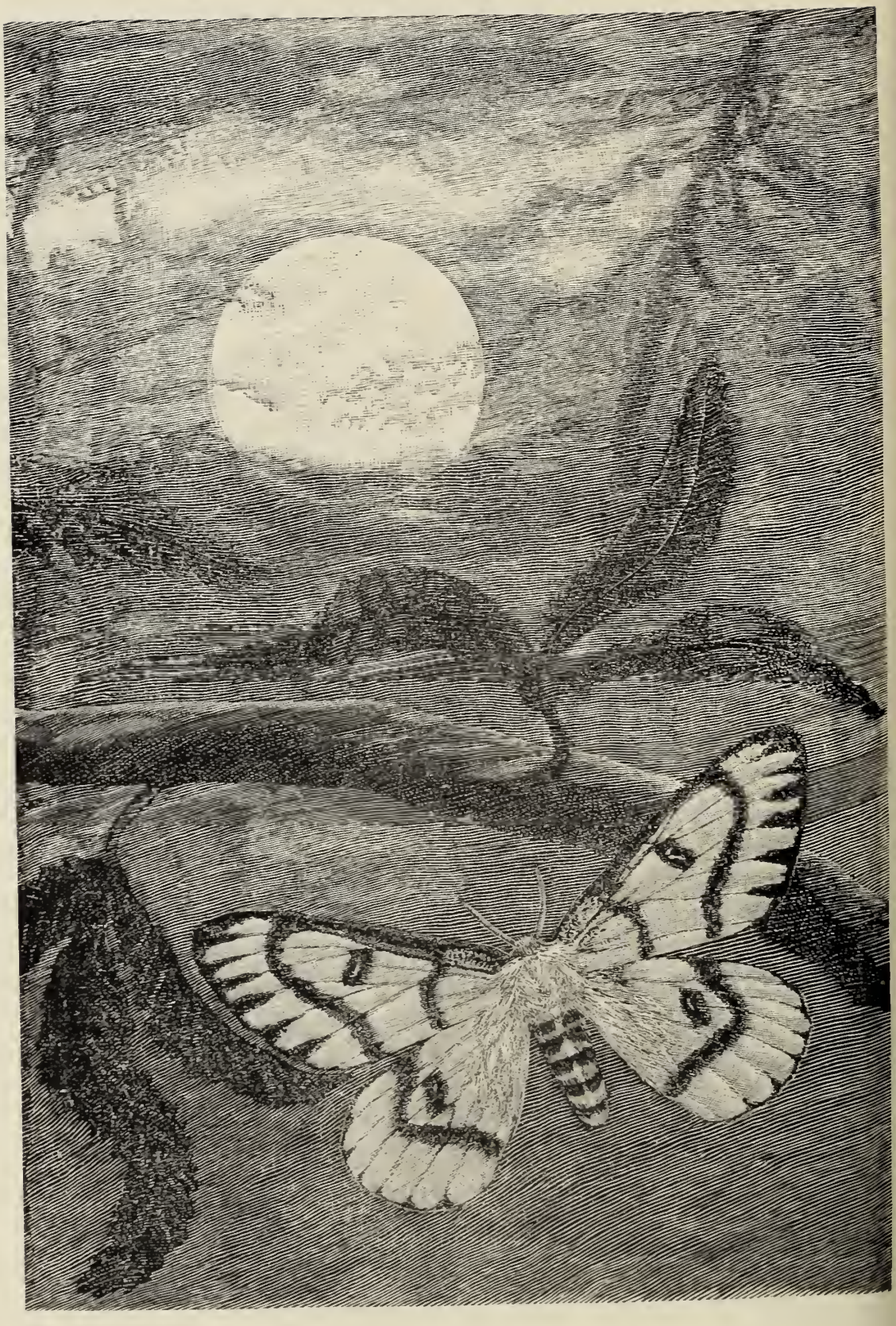


FIG 420.—Wings of *Hemileuca maia*.

Our best-known representative is the Maia-moth, *Hemileuca maia* (Hem-i-leu'ca ma'i-a). In this species (Fig. 421) the wings are thinly scaled, sometimes semi-transparent;

Plate IV.



they are black with a common white band near their middle; and the discal veins are usually white and broadly bordered with black. There are great variations in the width of the white band on the wings. The larva feeds on the leaves of oak; it is brownish black, with a lateral yellow stripe; and is armed on each segment with large branching spines. This species pertains to the eastern part of the continent; but there are several western species belonging to the genus.

FIG. 421.—*Hemileuca maia.*

In the West there occur also two species of the genus *Pseudohazis* (Pseu-do-ha'zis). These are *P. hera* (P. he'ra), in which the ground-color of the wings is white (Plate IV), and *P. eglanterina* (P. eg-lan-te-ri'na), in which the ground-color is brown. Both species are spotted and striped with black. In each the abdomen is ringed with black; there is a large discal spot on each wing, which frequently has a white center due to white scales borne by the discal vein. The base of the wings is dusky. There is a transverse band at the end of the basal third, which is sometimes wanting on the hind wings; and a broader, wavy, transverse band crossing both wings at the end of the basal two thirds; and on each wing there is a series of six or seven triangular black spots situated on the ends of the veins, at the outer margin of the wing. It should be said that both in the ground-color and in the markings these two forms vary much; and it is possible that they are merely varieties of one species.

Family CITHERONIIDÆ (Cith-e-ro-ni'i-dæ).

The Royal-moths.

The Royal-moths are stout-bodied and hairy, with sunken heads and strong wings. The species are of medium or large

size, some of them being nearly as large as the largest of our moths. The most obvious character limiting this family is the structure of the antennæ of the male. These agree with those of the Saturniidæ in having two pairs of teeth to each segment, but differ in being pectinated for only a little more than half their length. These moths also differ from most Saturniidæ in having two anal veins in the hind wings. Although the antennæ of the male are broadly pectinated, those of the female are filiform. The palpi and maxillæ are very small. The thorax and abdomen are densely clothed

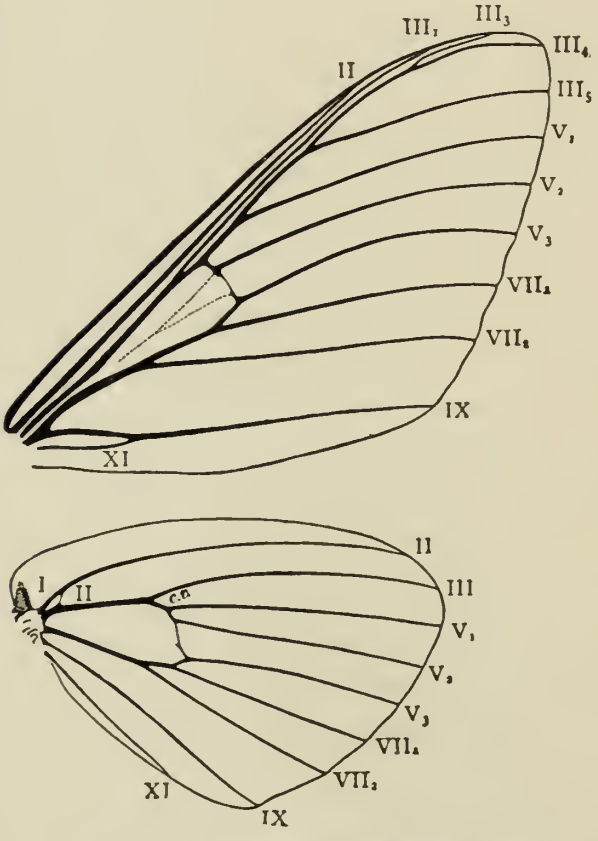


FIG. 422.—Wings of *Citheronia regalis*

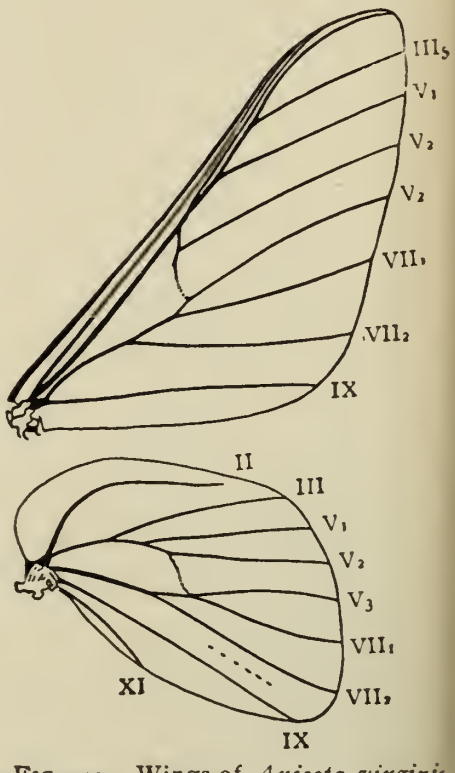


FIG. 423.—Wings of *Anisota virginiensis*.

with long hairs. The wings are strong, with prominent veins. The frenulum is wanting, and the humeral angle of the hind wings is very largely developed. In the fore wings vein V_2 arises from the discal vein (Figs. 422, 423).

The larvæ are armed with horns or spines, of which those on the second thoracic segment, and sometimes also

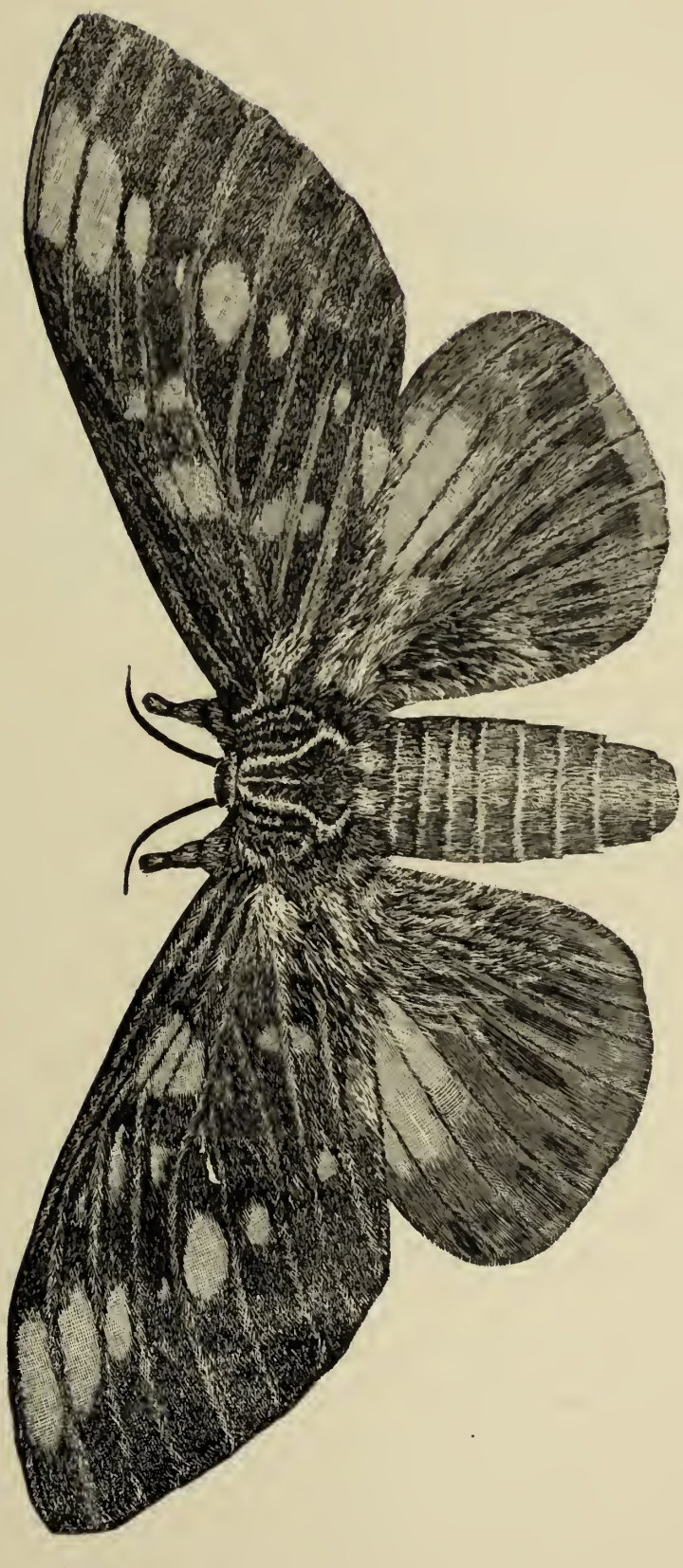


FIG. 424.—*Citheronia regalis.*

those on the third, are long and curved. These caterpillars eat the leaves of forest-trees, and go into the ground to transform, which they do without making cocoons. The rings of the pupa bear little notched ridges, the teeth of which, together with some strong prickles at the hinder end of the body, assist it in forcing its way upwards out of the earth.

This is a small family; it is not represented in Europe, and less than twenty species are known to occur in this country. The more common ones are the following:—

The Regal-moth, *Citheronia regalis* (Cith-e-ro′ni-a re-ga′-lis).—This is the largest and most magnificent of the Royal-moths (Fig. 424). The fore wings are olive-colored, spotted with yellow, and with the veins heavily bordered with red scales. The hind wings are orange-red, spotted with yellow, and with a more or less distinctly marked band outside the middle olive. The wings expand from four to six inches.

When fully grown the larva measures from four to five inches in length. It is our largest caterpillar, and can be readily recognized by the very long spiny horns with which it is armed. Those of the mesothorax and metathorax are much longer than the others. Of these there are four on each segment; the intermediate ones measure about three fifths inch in length. This larva feeds on various trees and shrubs.

The Imperial-moth, *Basilona imperialis* (Bas-i-lo′na im-pe-ri-a′lis).—This moth rivals the preceding species in size, expanding from four to five and one half inches. It is sulphur-yellow, banded and speckled with purplish brown. The full-grown larva (Fig. 425) measures from three to four inches in length. It is thinly clothed with long hairs, and bears prominent spiny horns on the second and third thoracic segments. In the early larval stages these thoracic horns are very long and spiny, resembling those of the larva of the Regal-moth. The larva feeds on hickory butternut, and other forest-trees.

The Two-colored Royal-moth, *Sphingicampa bicolor*

(Sphin-gi-cam'pa bi'co-lor).—In this species the upper side of the fore wings and the under side of the hind wings are yellowish brown, speckled with black. The under side of the fore wings and the upper side of the hind wings are to a con-

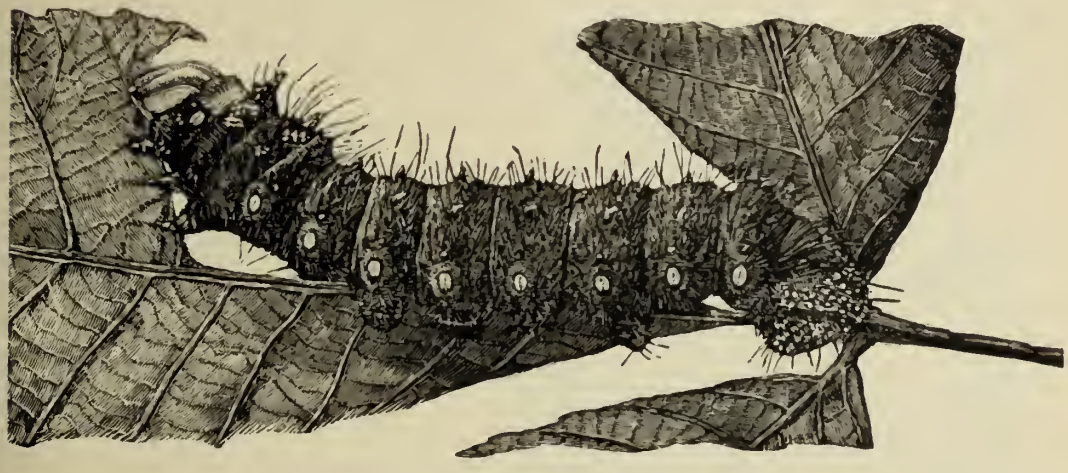


FIG. 425.—*Basilona imperialis*, larva.

siderable extent pink. There is usually a dark discal spot on the fore wings, upon which, especially in the males, there may be two white dots. This species is more common in the Southern States than in the North. The expanse of wings in the male is two inches; in the female, two and one half inches. The larva feeds on the leaves of the Honey-locust and of the Kentucky Coffee-tree.

Anisota (An-i-so'ta).—To the genus *Anisota* belong three species of moths that occur in the Eastern United States. These moths are dark yellow, purplish red, or brownish in color, and agree in having the fore wings marked with a white discal dot. The larvæ feed on the leaves of oak; they are more or less striped and are armed with spines. These insects hibernate as pupæ.

In determining these moths the student should remember that the two sexes of the same species may differ more in appearance than do individuals of different species but of the same sex. The sexes can be distinguished, as already indicated, by the antennæ. The three species can be separated as follows:—

The Rosy-striped Oak-worm, *Anisota virginiensis* (A. vir-gin-i-en'sis).—The wings of the female are purplish red, blended with ochre-yellow; they are very thinly scaled, and consequently almost transparent; and are not speckled with small dark spots (Fig. 426). The wings of the male are

FIG. 426.—*Anisota virginiensis*, female.

FIG. 427.—*Anisota virginiensis*, male.

purplish brown, with a large transparent space on the middle (Fig. 427). The larva is of an obscure gray or greenish color, with dull brownish yellow or rosy stripes, and with its skin rough with small white warts. There is a row of short spines on each segment, and two long spines on the mesothorax.

The Orange-striped Oak-worm, *Anisota senatoria* (A. sen-a-to'ri-a).—The wings of the female are more thickly scaled than in the preceding species and are sprinkled with numerous blackish dots; in other respects the two are quite similar in coloring. The male differs from that of *A. virginiensis* in lacking the large transparent space on the middle of the wings. The larva is black, with four orange-yellow stripes on the back and two along each side; its spines are similar to those of the preceding species.

The Spiny Oak-worm, *Anisota stigma* (A. stig'ma).—The female closely resembles that of *A. senatoria;* and as both species are variable it is sometimes difficult to determine to which a given specimen belongs. In *A. stigma* the wings are rather darker and have a greater number of blackish spots, and the hind wings are furnished with a middle band which is heavier and more distinct than in *A. senatoria.* The male differs from that of the other two species in quite closely

resembling the female in coloring, and in having the wings speckled. The larva differs from the other species of *Anisota* in having long spines on the dorsal aspect of the third thoracic and each abdominal segment in addition to the much longer spines on the mesothorax. It is of a bright tawny or orange color, with a dusky stripe along its back and dusky bands along its sides.

The Rosy Dryocampa, *Dryocampa rubicunda* (Dry-o-cam'pa ru-bi-cun'da).—The wings of this moth (Fig. 428) are pale yellow, banded with rose-color. The distribution of the color varies greatly in different specimens. In some the pink of the fore wings predominates, the yellow being reduced to a broad discal band, while in one variety the ground-color is yellowish white and the pink is reduced to a shade at the base and a narrow stripe outside the middle. The hind wings may be entirely yellow, or may have a pink band outside the middle. The expanse of wings in the male is one and one half to one and three fourths inches; in the female, two inches or more.

FIG. 428.—*Dryocampa rubicunda.*

The larva of this species is known as the Green-striped Maple-worm, and is sometimes a serious pest on soft-maple shade-trees. It measures when full grown about one and one half inches. It is pale yellowish green, striped above with eight very light, yellowish-green lines, alternating with seven of a darker green, inclining to black. There are two prominent horns on the second thoracic segment, and two rows of spines on each side of the body, one above and one below the spiracles. And on the eighth and ninth abdominal segments there are four prominent dorsal spines. The species is one- or two-brooded, and winters in the pupa state.

Family SATURNIIDÆ (Sat-ur-ni'i-dæ).

The Giant Silk-worms.

The large size of the members of the Saturniidæ, and the ease with which the cocoons of most of the species can be collected, render them well known to every beginner in the study of entomology. The family includes our largest lepidopterous insects; and all of the species known to us are above medium size. They are stout-bodied, hairy moths, with more or less sunken heads, and strong, wide wings. They may be distinguished from the Citheroniidæ, some of which rival them in size, by the form of the antennæ of the males, and by the fact that except in the lowest genus, *Coloradia*, which is a rare insect from the far West, the hind wings are furnished with only one inner vein. The adults fly at night, and are attracted by lights.

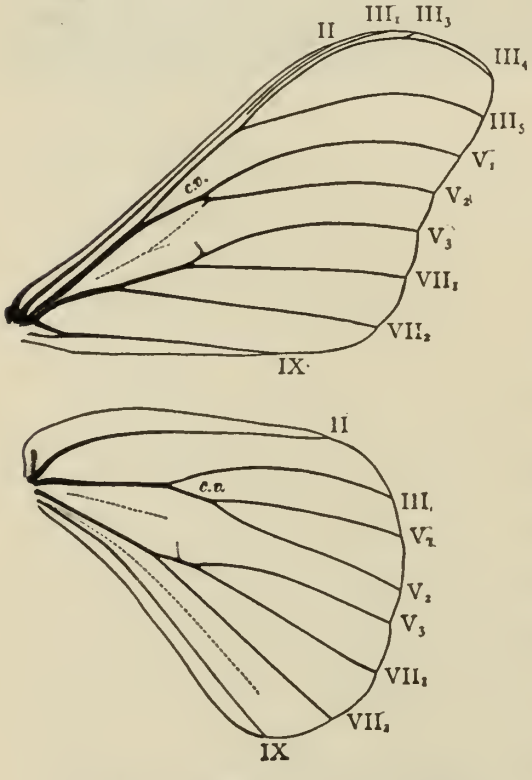


FIG. 429.—Wings of *Samia cecropia*.

The head is small and deeply sunken in the thorax; the antennæ are either filiform or pectinated in the females, but always pectinated in the males; and the pectinations extend to the tip. Where the antennæ of both sexes are pectinated, the males can be distinguished by the larger size of their antennæ. The palpi are small, and the maxillæ but little developed, often obsolete.

The thorax is densely clothed with hair. The wings are broad, and are often furnished with transparent, window-like spots. The frenulum is wanting. The humeral angle

of the hind wing is largely developed, and is usually strengthened by a deep furrow, the bottom of which is sometimes thickened so as to appear like a humeral vein (Fig. 429).

The larvæ live exposed on the leaves of trees and shrubs; they are more or less armed with tubercles and spines, and are very conspicuous on account of their large size. They transform within silken cocoons, which are usually very dense, and in some cases have been utilized by man. These cocoons are often attached to trees and shrubs, and are sometimes inclosed in a leaf. They can be easily collected during the winter months, and the adults bred from them.

The following species are those that the young student is most likely to find:—

The Io-moth, *Automeris io* (Au-tom′e-ris i′o).—This is the most common of the smaller species of the family. The female is represented by Figure 430. In this sex the

FIG. 430.—*Automeris io.*

ground-color of the fore wings is purplish red. The male differs greatly in appearance from the female, being somewhat smaller and of a deep yellow color, but it can be easily recognized by its general resemblance to the female in other respects.

The larva is one that the student should learn to recognize in order that he may avoid handling it; for it is armed

with spines the prick of which is venomous (Fig. 431). It is green, with a broad brown or reddish stripe, edged below with white, on each side of the abdomen. The spines are tipped with black.

FIG. 431.—*Automeris io*, larva.

The Polyphemus-moth, *Telea polyphemus* (Te'le a pol-y-phe'mus).—This is a yellowish or brownish moth with a window-like spot in each wing. There is a gray band on the costal margin of the fore wings; and near the outer margin of both pairs of wings there is a dusky band, edged

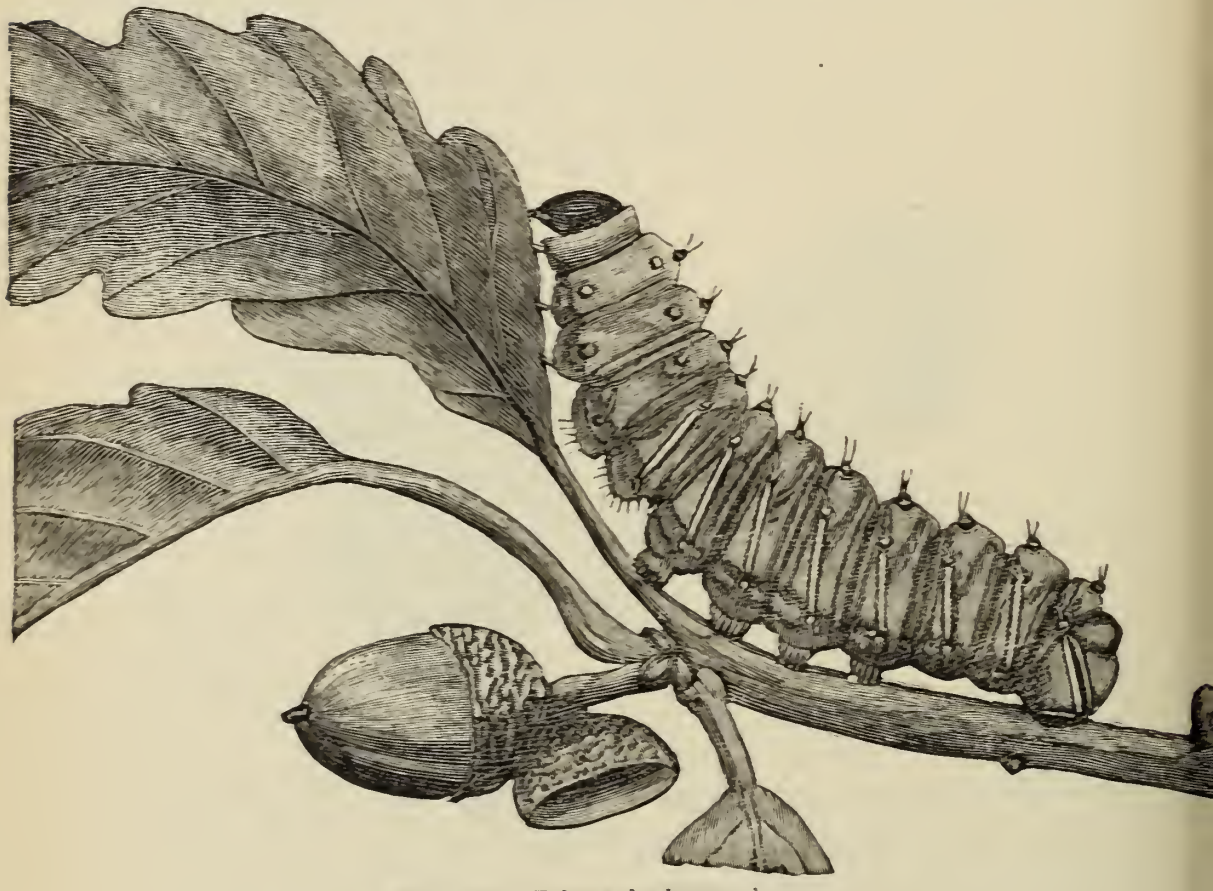
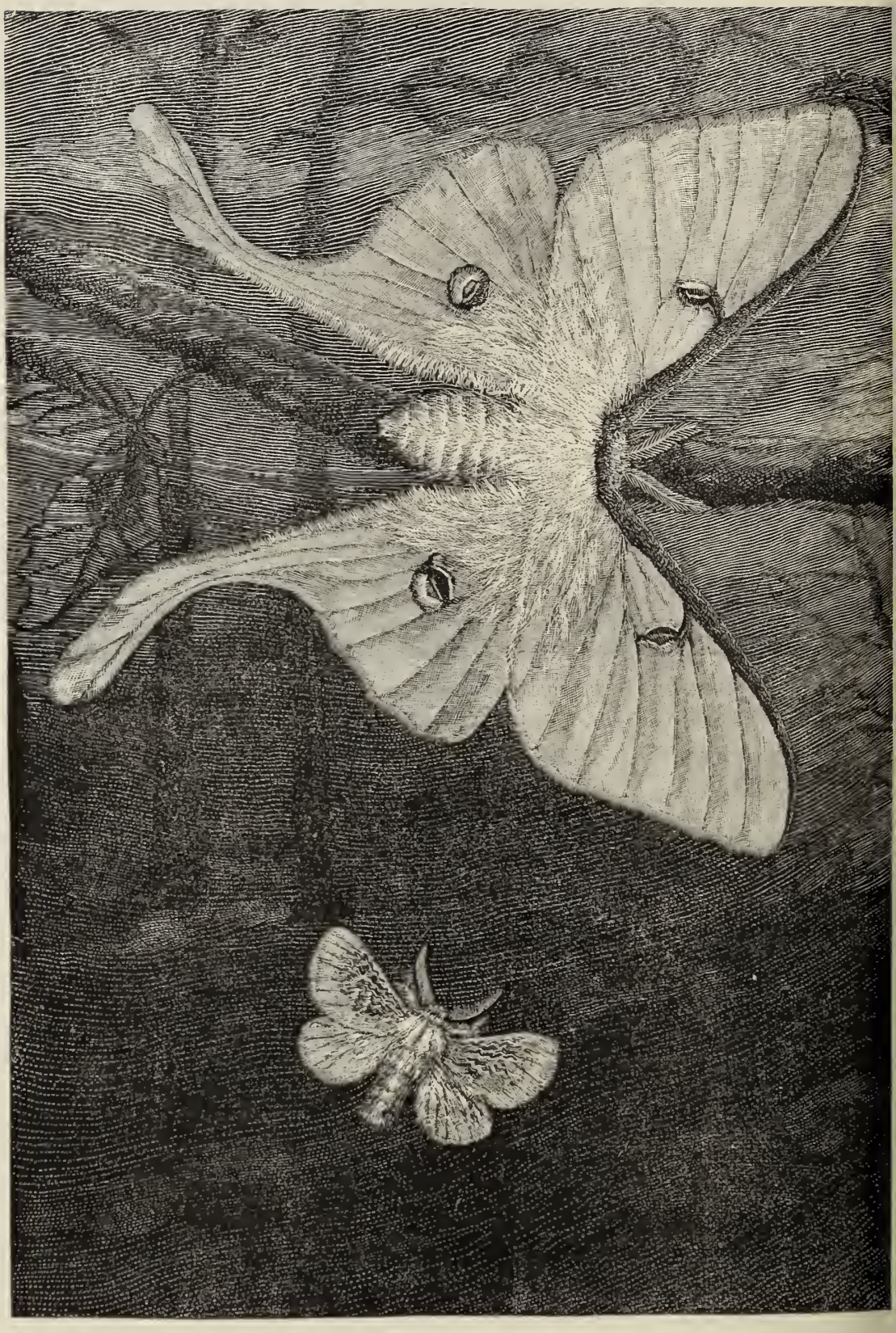


FIG. 432.—*Telea polyphemus*, larva.

without with pink; the fore wings are crossed by a broken dusky or reddish line near the base, edged within with white or pink. The transparent spot on each wing is divided by the discal vein, and encircled by yellow and black rings.

Plate V.



On the hind wings the black surrounding the transparent spot is much widened, especially toward the base of the wing, and is sprinkled with blue scales. The wings expand from five to six inches.

The larva (Fig. 432) feeds on oak, butternut, basswood, elm, maple, apple, plum, and other trees. When full grown it measures three inches or more in length. It is of a light green color with an oblique yellow line on each side of each abdominal segment except the first and last; the last segment is bordered by a purplish-brown V-shaped mark. The tubercles on the body are small, of an orange color with metallic reflections. The cocoon (Fig. 433) is dense and usually enclosed in a leaf; it can be utilized for the manufacture of silk. When the adult is ready to emerge, it excretes a fluid which softens the cocoon at one end, and breaking the threads it makes its exit through a large round hole.

FIG. 433.—*Telea polyphemus.*

The Luna Moth, *Tropæa luna* (Tro-pæ'a lu'na).—This magnificent moth is a great favorite with amateur collectors (Plate V). Its wings are of a delicate light green color, with a purple-brown band on the costa of the fore wings; there is an eye-like spot with a transparent center on the discal vein of each wing; and the anal angle of the hind wings is greatly prolonged. The larva feeds on the leaves of walnut, hickory, and other forest-trees. It measures when full grown about three inches in length. It is pale bluish green with a pearl-colored head. It has a pale yellow stripe along each side of the body, and a transverse yellow line on the back between each two abdominal segments. The cocoon resembles that of the preceding species in form, but is very thin, containing but little silk.

The Promethea Moth, *Callosamia promethea* (Cal-lo-sa'mi-a pro-me'the-a).—This is the most common of the Giant Silkworms. The wings of the female (Fig. 434) are light reddish

FIG. 434.—*Callosamia promethea*, female.

brown; the transverse line crossing the middle of the wings is whitish, bordered within with black; the outer margin of the wings is clay-colored, and each wing bears an angular discal spot. The discal spots vary in size and distinctness in different specimens. The male differs so greatly from the female that it is liable to be mistaken for a distinct species. It is blackish, with the transverse lines very faint, and with the discal spots wanting or very faintly indicated. The fore wings also differ markedly in shape from those of the female, the apex being much more distinctly sickle shaped. The larva when full grown measures two inches or more in length. It is of a clear and pale bluish-green color; the legs and anal shield are yellowish; and the body is armed with longitudinal rows of tubercles. The tubercles are black, polished, wart-like elevations, excepting two each on the second and third thoracic segments, which are larger and rich coral-red, and one similar in size to these but of a yellow color on the eighth abdominal segment. This larva feeds on the leaves

of a large proportion of our common fruit and forest trees; but we have found it more frequently on wild cherry and ash than on others. The cocoons can be easily collected during the winter from these trees. This is the best way to obtain fresh specimens of the moths, which will emerge from the cocoons in the spring or early summer. The cocoon (Fig. 435) is interesting in structure. It is greatly elongated and is enclosed in a leaf, the petiole of which is securely fastened to the branch by a band of silk extending from the cocoon; thus the leaf and enclosed cocoon hang upon the tree throughout the winter. At the upper end of the cocoon there is a conical valve like arrangement which allows the adult to emerge without the necessity of making a hole through the cocoon. This structure is characteristic of the cocoons of the moths of this and the following genus.

FIG. 435.—*Callosamia promethea*, cocoon.

The Angulifera Moth, *Callosamia angulifera* (C. an-gu-lif'e-ra).—This is a somewhat rare insect which so closely resembles the Promethea Moth that by many it is considered a variety of it. Specimens of it are usually a little larger than those of C. *promethea*, and the transverse line and discal spots are more angular. The most important differences, however, are presented by the male, which quite closely resembles the female

of the Promethea Moth in color and markings, and thus differs decidedly from the male of that species.

The Cecropia Moth, *Samia cecropia* (Sa'mi-a ce-cro'pi-a).—This is the largest of our Giant Silk-worms, the wings of the adult expanding from five to six and one half inches. The ground color of the wings is a grizzled dusky brown, especially on the central area. The wings are crossed beyond the middle by a white band, which is broadly margined without with red. and there is a red spot near the apex of the fore wing just outside of a zigzag line. Each wing bears near its center a crescent-shaped white spot bordered with red. The outer margin of the wings is clay-colored. The larva is known to feed on at least fifty species of plants, including apple, plum, and the more common forest trees. When full grown it measures from three to four inches in length and is dull bluish green in color. The body is armed with six rows of tubercles, extending nearly its entire length, and there is an additional short row on each side on the ventral aspect of the first five segments following the head. The tubercles on the second and third thoracic segments are larger than the others, and are coral-red. The other dorsal tubercles are yellow, excepting those of the first thoracic and last abdominal segments, which with the lateral tubercles are blue; all are armed with black bristles. The

FIG. 436.—*Samia cecropia*, pupa.

FIG. 437.—*Samia cecropia*, cocoon.

pupa is represented by Figure 436 and the cocoon by Figure 437.

The Cecropia-moth occurs from the Atlantic coast to the Rocky Mountains. In the far West its place is taken by very closely allied forms, which are supposed to be distinct. In these the ground-color of the wings is usually a reddish or dusky brown. The form occurring in Utah and Arizona is *Samia gloveri* (S. glov'er-i); that found on the Pacific coast is *Samia californica.*

The Ailanthus-worm, *Philosamia cynthia* (Phil-o-sa'mi-a cyn'thi-a), is an Asiatic species that has been introduced into this country. It has become a pest in the vicinity of New York, where it infests the Ailanthus shade-trees. The moth differs from all our native species of this family in having rows of tufts of white hairs on the abdomen. The cocoon resembles that of the Promethea-moth.

Family LACOSOMIDÆ (Lac-o-som'i-dæ).

The Sack-bearing Frenulum-losers.

This family so far as is now known includes only two species that are found in the United States, and both of these are rare; farther south several other species occur. They are our only native Frenulum-losers that retain a rudiment of the frenulum, but, as in the silk-worm, this frenulum is very small and the humeral angle is greatly expanded, so it is probable that the frenulum is of but little if any use (Fig. 438). It was the presence of this rudiment that first suggested to the writer that those families of the Lepidoptera that we have termed Frenulum-losers were descended from frenulum-bearing ancestors.

The Lacosomidæ seem to be the sole survivors of a very distinct line of descent. In many respects they appear to be closely allied to the Saturniina, especially to the Bombycidæ. But they differ markedly both in the structure and in the habits of the larvæ; and, too, the wings of the adult,

although at first sight resembling those of the silk-worm, are really quite different. In the coalescence of the branches of radius of the fore wings veins III_3 and III_4 remain separate, while in the Saturniina these are the first branches to coalesce. And in the hind wings there is no indication that vein I becomes joined to the base of vein II as is shown to be the case in the most generalized Saturniina (Figs. 417 and 419).

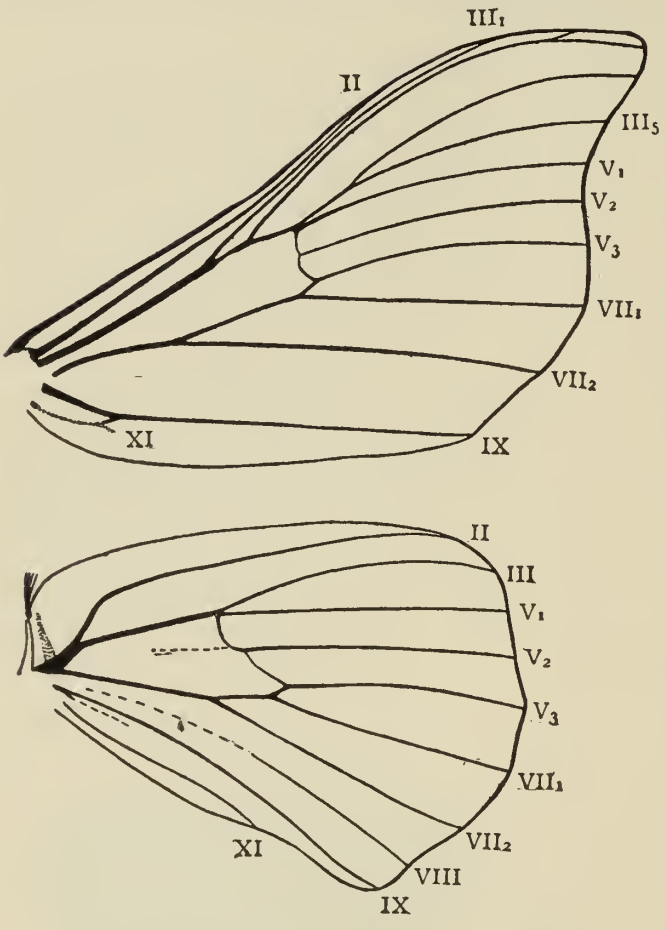


FIG. 438.—Wings of *Cicinnus melsheimerii*.

The members of this family in the larval state feed upon leaves, and protect themselves by making a case of leaves within which they live (Fig. 439).

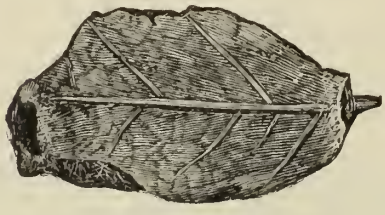


FIG. 439.—Case of larva of *Cicinnus*.

FIG. 440.—*Cicinnus melsheimerii*.

Melsheimer's Sack-bearer, *Cicinnus melsheimerii* (Ci-cin′-nus mels-hei-me′ri-i).—The larva of this species feeds on oak. The adult moth (Fig. 440) is of a reddish gray color, finely sprinkled all over with minute black dots; there is a small black spot at the end of the discal cell of the fore wings;

and both pairs of wings are crossed by a narrow blackish band. This species is quite widely distributed; but is quite rare in most places.

The other representative of this family found in the United States is *Lacosoma chiridota* (Lac-o-so′ma chir-i-do′-ta). This species is even more rare than the preceding; it is somewhat smaller, and dark yellowish brown in color; but its general appearance is very similar. The venation of the wings is also similar to that of *Cicinnus* except that vein VIII of the hind wing is wanting.

Family LASIOCAMPIDÆ (Las-i-o-cam′pi-dæ).

The Lasiocampids (*Las-i-o-cam′pids*).

This family includes the Tent-caterpillars and the Lappet-caterpillars. The adults are stout-bodied, hairy moths of medium size. The antennæ are pectinated in both sexes, and are from one fourth to one half as long as the front wings; the teeth of the antennæ of the male are usually much longer than those of the female. The ocelli are wanting; and the palpi are usually short and woolly. But the most distinctive characteristic is found in the wings. The frenulum is wanting, there being instead, as in the Saturniina, a largely-expanded humeral angle of the hind wings. But these moths differ from the Saturniina in having cubitus apparently four-branched and in having the humeral angle

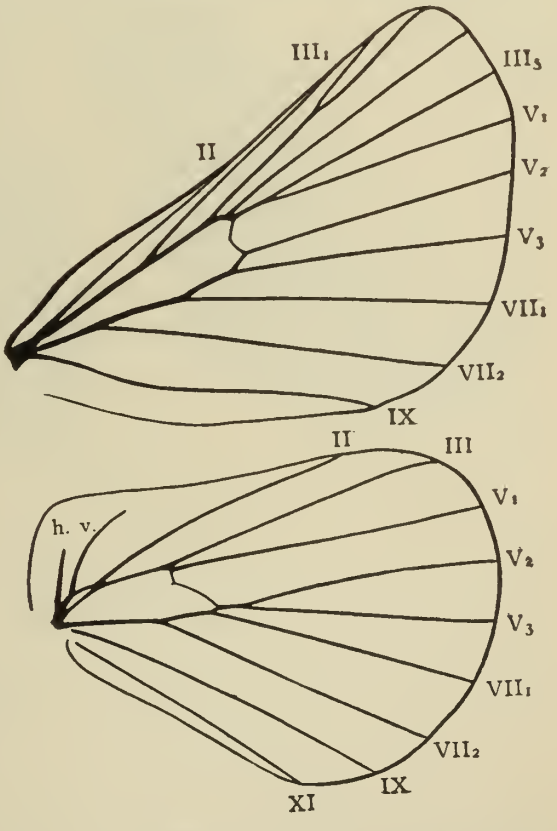


FIG. 441.—Wings of *Clisiocampa americana.*

strengthened by the development of some extra veins, the *humeral veins* (Fig. 441, *h. v.*).*

The larvæ of the Lasiocampids feed upon the foliage of trees, and are frequently very destructive.

The family is a small one, less than thirty North American species being known to entomologists. Our more common ones represent three genera: *Clisiocampa* (Clis-i-o-cam′-pa), which includes the Tent-caterpillars, and *Phyllodesma* (Phyl-lo-des′ma) and *Tolype* (Tol′y-pe), which include the Lappet-caterpillars.

There are several species of Tent-caterpillars in this country. Most of them belong to the Pacific coast; but two are common in the East. Of these the most common one is the Apple-tree Tent-caterpillar, *Clisiocampa americana* (C. a-mer-i-ca′na). This is the insect that builds large webs in apple and wild cherry trees in early spring. Figure 442 represents its transformations. The moth is dull yellowish brown or reddish brown, with two transverse whitish or pale yellowish lines on the fore wings. The figure represents a male; the female is somewhat larger. These moths appear early in the summer. The eggs are soon laid, each female laying all her eggs in a single ring-like cluster about a twig; and here they remain unhatched for about nine months. This cluster is covered with a substance which protects it during the winter. The eggs hatch in early spring, at the time or just before the leaves appear. The larvæ that hatch early feed upon the unopened buds till the leaves expand. The larvæ are social, the entire brood that hatch from a cluster of eggs keeping together and building a tent in which they live when not feeding. The figure represents a specimen in our collection. In this case the tent was begun near the cluster of eggs. But usu-

* So far as we know, humeral veins occur nowhere else in the Lepidoptera, although in many butterflies vein I of the hind wings is preserved and appears like a humeral vein. The humeral veins of the Lasiocampidæ do not represent any of the primitive veins, but are developed secondarily.

ally the larvæ soon after hatching migrate down the branch towards the trunk of the tree until a fork of considerable size is reached before they begin their tent. This is necessary, as the completed tent often measures two feet or more in length. The larvæ leave the nest daily in order to feed; and spin a silken thread wherever they go. The larvæ be-

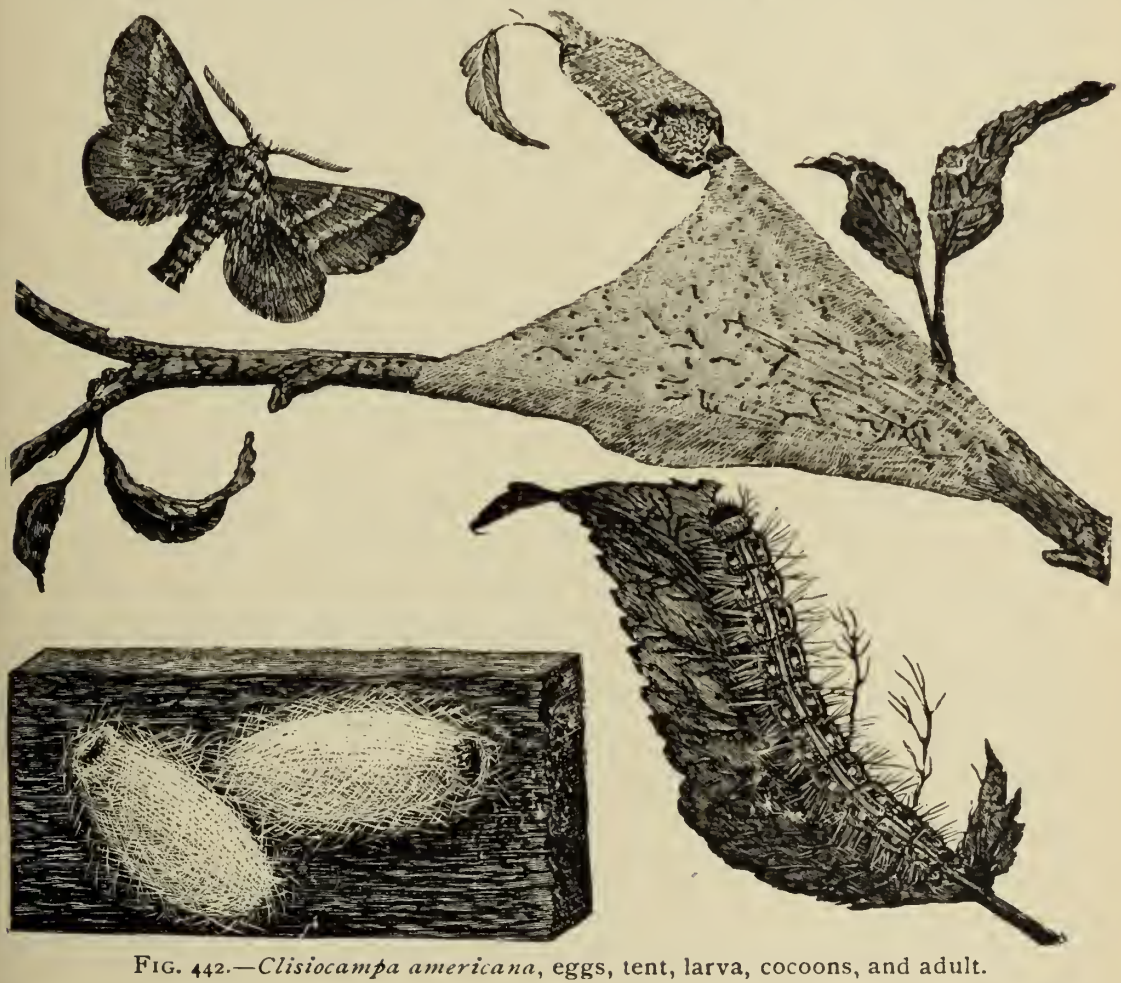


FIG. 442.—*Clisiocampa americana*, eggs, tent, larva, cocoons, and adult.

come full grown early in June; one of them is represented on a partially-eaten leaf in the figure. When ready to transform they leave the trees and make their cocoons in some sheltered place. These cocoons are quite peculiar in appearance, having a yellowish white powder mixed with the silk. The pupa state lasts about three weeks.

The easiest way to fight this pest is to destroy the webs containing the larvæ as soon as they appear in the spring. This should be done early in the morning, or late in the

afternoon, or on a cold day, when the larvæ are not scattered over the tree feeding.

The other Eastern species of this genus is the Tent-caterpillar of the Forest, *Clisiocampa disstria* (C. dis'stri-a). This species resembles the preceding in habits. It is more apt, however, to feed upon forest-trees. The moth differs from *C. americana* in having the oblique lines on the wings dark instead of light; the larva differs in having a row of spots along the back instead of a continuous narrow line; and the egg-masses differ in ending squarely instead of being rounded at each end.

The more common species of the Pacific coast are *Clisiocampa californica*, whose nests may be found on oaks in March and April, and *Clisiocampa constricta*, which infests fruit-trees later in the season. The caterpillars of the last-named species do not make a tent, although they live in colonies.

The larvæ of *Tolype* and *Phyllodesma* are remarkable for having on each side of each segment a little lappet or flat lobe; from these many long hairs are given out, forming a fringe to the body. When at rest the body of the larva is flattened, and the fringes on the sides are closely applied to the surface of the limb on which the insect is. Thus all appearance of an abrupt elevation is obliterated; the colors of these larvæ are also protective, resembling those of the bark.

The genus *Tolype* includes only two common North American species; both of these occur in the East. The more common of the two is the Velleda Lappet, *Tolype velleda* (Tol'y-pe vel'le-da). The body of the moth is milk-white, with a large blackish spot on the middle of its back (Fig. 443). That part of this spot which is on the thorax is composed of erect scales; the cau-

FIG 443.—*Tolype velleda.*

dal part, of recumbent hairs. The wings are dusky gray, crossed by white lines as shown in the figure. The figure represents the male ; the female is much larger. The moths are found in August and September. The larva feeds upon the leaves of apple, poplar, and syringa. Its body is bluish gray, with many faint longitudinal lines ; and across the back of the last thoracic segment there is a narrow velvety-black band. The larva reaches maturity during July. The cocoon is brownish gray, and is usually attached to one of the branches of the tree on which the larva has fed.

The second species of this genus is known as the Larch Lappet, *Tolype laricis* (T. lar'i-cis). This is a smaller species, the females being about the size of the male of the preceding species, and the males expanding only about one and one fourth inches. The wings of the females are marked much like those of *T. velleda*, except that the basal two thirds of the front wings are much lighter, and the dark band on the outer third is narrower and much darker than the other dark bands. The males are bluish black, with the markings indistinct. The larva feeds upon the larch. When mature it is of a dull brown color and less than one and one half inches in length. When extended the front of the first thoracic segment is pale green, and the incision between the second and third is shining black. The larva matures during July. The cocoon is ash-gray, flattened and moulded to the limb to which it is attached, and partially surrounding it. The moths appear in August or September. The winter is passed in the egg state.

The genus *Phyllodesma* includes three Californian and two Eastern species. The more common one of the latter is the American Lappet, *P. americana* (Fig. 444). The moth is reddish brown, with the inner angle of the front wings and the costal margin of the hind wings deeply notched. Beyond the mid-

FIG. 444.—*Phyllodesma americana.*

dle of each wing there is a pale band edged with zigzag, dark brown lines. The larva lives upon apple, cherry, oak, birch, maple, and ash. When full grown it measures two and one half inches in length and one half inch in breadth. The upper side is slate-gray, mottled with black, with two transverse scarlet bands, one on the second and one on the third thoracic segments. There is a black spot at each end and in the middle of each of these bands. The larva is found during July and August. It is said that the cocoons are attached to limbs like those of Tolype; but the larvæ of this species which we have bred made their cocoons between leaves, or in the folds of the muslin bag enclosing the limb upon which they were feeding. The species passes the winter in the pupa state; and the moth appears in June, when it lays its eggs upon the leaves of the trees it infests.

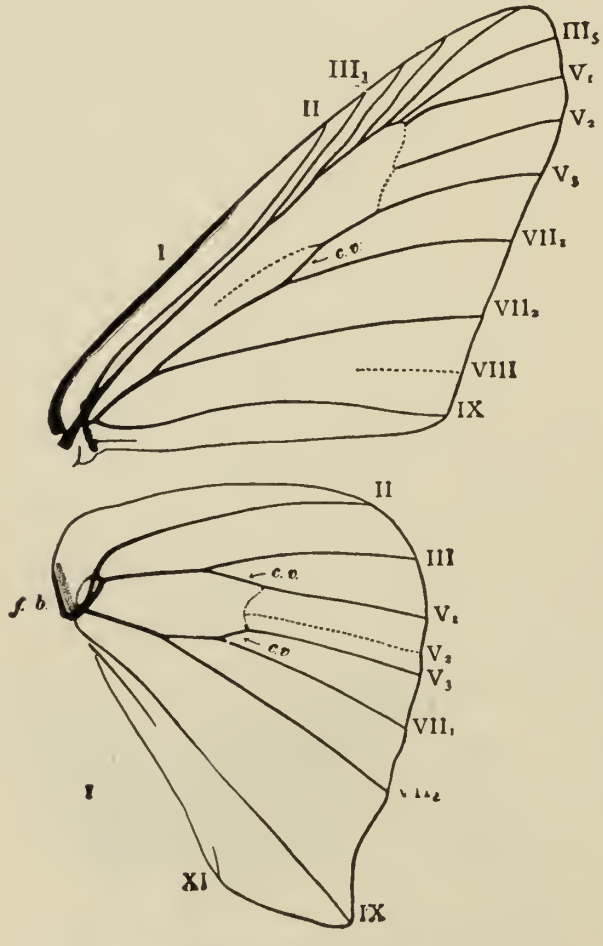


FIG. 445.—Wings of *Epargyreus tityrus*.

Superfamily HESPERIINA (Hes-per-i-i'na).

The Skippers.

The Skippers are so called on account of their peculiar mode of flight. They fly in the daytime and dart suddenly from place to place. When at rest most species hold the wings erect in a vertical position like butterflies; in some the fore wings are thus held while the hind wings are extended horizontally; and a few extend both pairs of wings horizontally. The antennæ

are thread-like, and enlarged toward the tip; but in most cases the extreme tip is pointed and recurved, forming a hook. The abdomen is usually stout, resembling that of a moth rather than that of a butterfly. The skippers are most easily distinguished by the peculiar venation of the fore wings, vein III being five-branched, and all the branches arising from the discal cell (Fig. 445). In some butterflies all the branches of vein III appear to arise from the discal cell; but this is because two of the branches coalesce to the margin of the wing. In such butterflies vein III appears to be only four-branched.

This superfamily includes two families—the Giant Skippers, *Megathymidæ*, and the Common Skippers, *Hesperiidæ*. These can be distinguished as follows:—

A. Head of moderate size; club of antenna large, neither drawn out at the tip nor recurved. Large skippers, with wing expanse of two inches or more. p. 365 ..... MEGATHYMIDÆ.

AA. Head very large; club of antenna usually drawn out at the tip, and with a distinct recurved apical crook. In a few forms the crook of the antennæ is wanting; such forms can be distinguished from the Megathymidæ by their smaller size, the wing expanse being less than one and one fourth inches. p. 368. HESPERIIDÆ.

Family MEGATHYMIDÆ (Meg-a-thym'i-dæ).

The Giant Skippers.

This family includes a small number of large skippers, which are found in the South and far West. In the adult insect the head is of moderate size, the width, including the eyes, being much less than that of the metathorax. The club of the antennæ is large; and, although the tip is turned slightly to one side, it is neither drawn out to a point nor recurved. The body is very robust, even more so than in the Hesperiidæ. These insects fly in the daytime and with a rapid, darting flight. When at rest they fold their wings in a vertical position.

In the more general features of their venation the wings

closely resemble those of the Hesperiidæ. But the Giant Skippers exhibit a very peculiar specialization of wing structure in the male sex. Here the two branches of vein VII of the fore wings separate from each other and from the cross-vein connecting them with vein V_3, near the base of the wing (Fig. 446). In this sex this cross-vein, the branches of

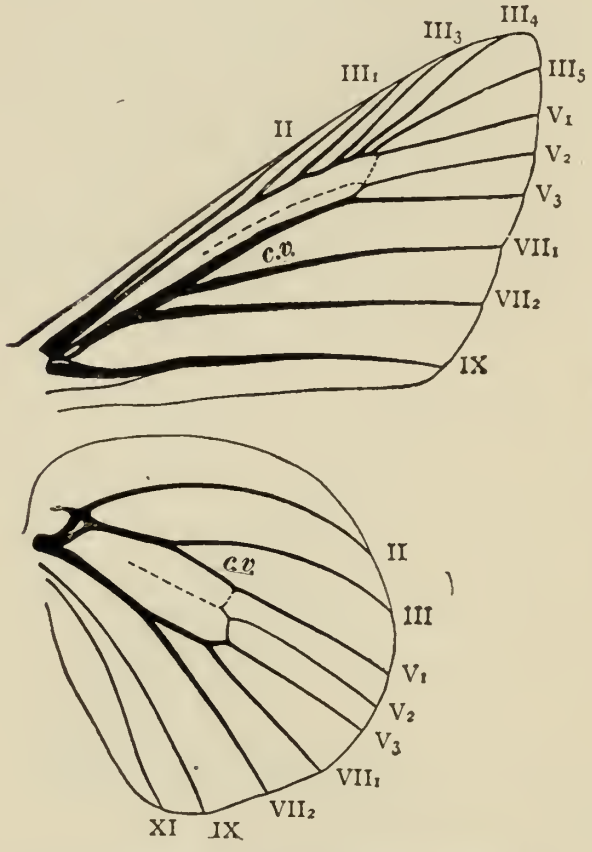


FIG. 446.—Wings of *Megathymus yuccæ*, male.

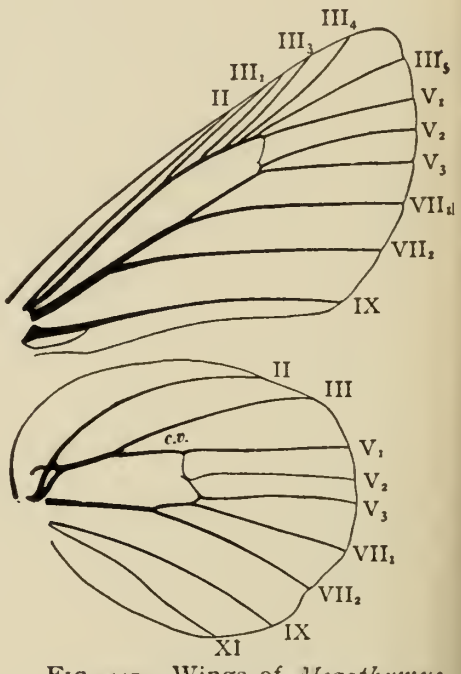


FIG. 447.—Wings of *Megathymus cofaqui*, female.

vein VII, and vein IX are all very stout. The strengthening of these veins is evidently a specialization that increases the power of flight of this sex. For these stout veins must aid in depressing the hind wings during the downward stroke of the wings, as the hind wing is overlapped by that part of the fore wing traversed by these veins. The separation of the branches of vein VII from each other and from the cross-vein, so near the base of the wing, is directly correlated with the strengthening of these veins. In the course of the perfecting of the powers of flight in the male these

veins have split apart, so that they overlie the hind wings to a greater extent than they do in the female (Fig. 447), which probably represents a more primitive condition. It is a common occurrence for the wings of the male to be more highly specialized than those of the female, for, in the seeking of mates, the males fly more than do the females. But it is unusual for veins to coalesce to a smaller extent in specialized forms than in those more generalized. In other words, the ordinary course of specialization is for veins to grow together instead of to split apart.

FIG. 448.—*Megathymus cofaqui.*

This family is represented in the United States by a single genus, of which only three species are known. The female of one of these, *Megathymus cofaqui* (Meg-a-thy'mus cof-a-qui'), is represented by Figure 448. The male differs in the smaller size of the spots on the fore wing, in lacking the band of spots on the hind wing, and in having the upper surface of the hind wing nearly covered with long fine black hairs, which stand nearly erect. This species has been found in Florida and Colorado.

A much better known species is the Yucca-borer, *Megathymus yuccæ* (M. yuc'cæ). The female of this species differs from that of the preceding in having much darker wings, all of the spots being smaller, and in having only one or two white spots on the lower surface of the hind wings. The male lacks the erect hairs on the hind wings. The larva bores in the stem and root of the Yucca or Spanish Bayonet. It differs greatly in appearance from the larvæ of the Hesperiidæ, having a small head. This species is widely distributed through the southern part of our country.

The third species, *Megathymus neumœgeni* (M. neu-mœ-gen'i), occurs in Arizona.

Family HESPERIIDÆ (Hes-pe-ri'i-dæ).

The Common Skippers.

The family Hesperiidæ includes all skippers found in the United States except the three species described above as the Giant Skippers. In addition to the differences indicated in the table (p. 365), it may be said that the males in the Hesperiidæ lack the peculiar thickening and splitting apart of the branches of vein VII of the fore wings characteristic of the Giant Skippers. But there exists instead in the males of nearly all species peculiar scent-organs, which are described later. Figure 449 represents the venation of a male member of this family.

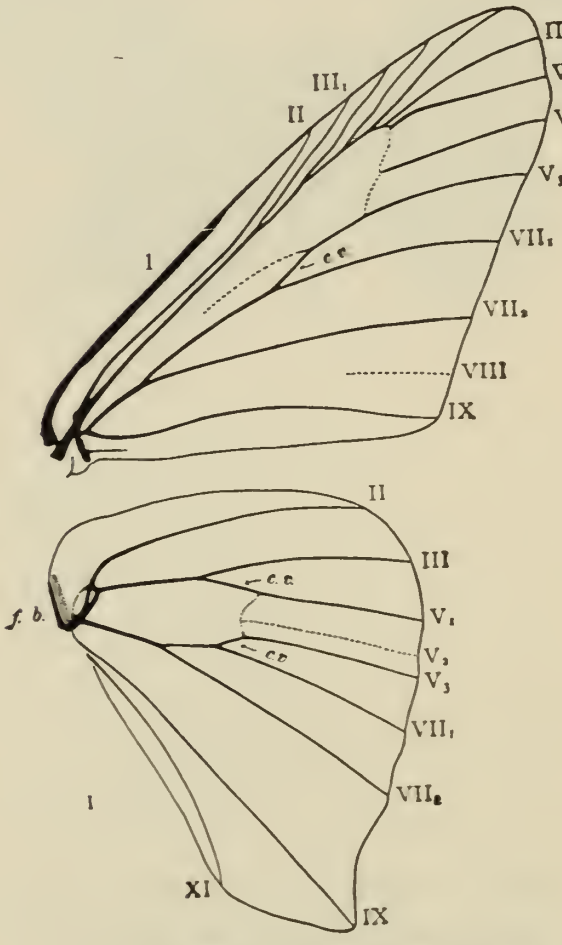


FIG. 449.—Wings of *Epargyreus tityrus*.

The larvæ of the Common Skippers present a very characteristic appearance, having large heads and strongly constricted necks (Fig. 450). They usually live concealed in a folded leaf or in a nest made of several leaves

FIG. 450.—*Epargyreus tityrus*, larva.

fastened together. The pupæ are rounded, not angular, resembling those of moths more than those of butterflies. The pupa state is passed in a slight cocoon, which is generally composed of leaves fastened together with silk, and thinly lined with the same substance.

The family Hesperiidæ includes three subfamilies; but only two of them are represented in this country, the third being confined to South and Central America. Our forms can be separated as follows:—

A. Vein V_2 of the fore wings arising nearer to vein V_1 than to vein V_3. p. 369.....HESPERIINÆ.

AA. Vein V_2 of the fore wings arising midway between veins V_1 and V_3 or nearer to vein V_3 than to vein V_1.

B. Vein V_2 of the fore wings arising nearly midway between veins V_1 and V_3.

C. Discal cell of fore wings more than two thirds as long as the costa. Males usually with costal fold in fore wings. p. 369. HESPERIINÆ.

CC. Discal cell of fore wings less than two thirds as long as the costa. Males usually with a discal patch on fore wings. p. 372.....PAMPHILINÆ.

BB. Vein V_2 of the fore wings arising much nearer to vein V_3 than to vein V_1. p. 372.....PAMPHILINÆ.

Subfamily HESPERIINÆ (Hes-pe-ri-i′næ).

Skippers with a Costal Fold.

This subfamily includes the larger of the Common Skippers, as well as some that are of moderate size. Most of the species are dark brown, marked with white or translucent, angular spots. The antennæ usually have a long club, which is bent at a considerable distance from the tip (Fig. 451). But the most distinctive feature of the subfamily is exhibited by the males alone, and is lacking in some species. It consists of a fold in the fore wing near the costal margin, which forms a long slit-like pocket, con-

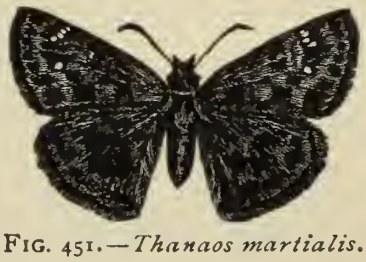


FIG. 451.—*Thanaos martialis.*

taining a sort of silky down. This is supposed to be a scent-organ. When this pocket is tightly closed it is difficult to see it.

Nearly seventy species belonging to this subfamily have been found in America north of Mexico. The following are some of the more common of these:—

The Silver-spotted Skipper, *Epargyreus tityrus* (Ep-ar-gy're-us tit'y-rus). — This skipper is represented on our colored plate (Plate I, Fig. 4). It is dark chocolate-brown, with a row of yellowish spots extending across the fore wing and with a large silvery-white spot on the lower side of the hind wing. It is found in nearly the whole United States, from Massachusetts to California, except in the extreme Northeast and Northwest. The larva (Fig. 450) feeds upon various papilionaceous plants. We have found it common on locust. It makes a nest, within which it remains concealed, by fastening together, with silk, the leaflets of a compound leaf (Fig. 452).

FIG. 452.—Nest of larva of *Epargyreus tityrus*.

The Long-tailed Skipper, *Eudamus proteus* (Eu'da-mus pro'te-us).—This Skipper by the shape of its wings reminds one of a swallow-tail butterfly, the hind wings being furnished with long tails. It expands about one and three fourths inches; and the greatest length of the hind wings is about one and one fourth inches. The wings are very dark chocolate-brown; the front wings contain several silvery-white spots; and the body and base of the wings bear metallic-

green hairs. The larvæ feed upon both Leguminosæ and Cruciferæ. In the South it is sometimes a pest in gardens, cutting and rolling the leaves of beans, turnips, and cabbage, and feeding within the rolls thus formed. It is found on the Atlantic border from New York southward into Mexico.

There are two common skippers which are nearly as large as the two described above, but which have neither the yellow band of the first nor the long tails of the second; neither do they have the brown spots characteristic of the following genus. These two skippers belong to the genus *Thorybes*. The wings are of an even dark brown; the fore wings are flecked with small or very small irregular white spots, and the hind wings are crossed beneath by two rather narrow, parallel, inconspicuous darker bands. These skippers are distinguished as follows:—

The Northern Cloudy-wing, *Thorybes pylades* (Thor'y-bes pyl'a-des).—In this species the white spots on the fore wing are usually mere points, although their number and size vary. The species is found in nearly all parts of the United States. The larva commonly feeds on clover.

The Southern Cloudy-wing, *Thorybes bathyllus* (T. ba-thyl'lus).—In this species the white spots are larger than in the preceding, almost forming a continuous band. This skipper is widely distributed over the eastern United States, except the more northern portions.

To the genus *Thanaos* belong a large number of species which on account of their dark colors have been named Dusky-wings. These species resemble each other so closely in markings that it is very difficult to separate them without longer descriptions than we can give here. The one following will serve as an example.

FIG. 453.—*Thanaos martialis*.

Martial's Dusky-wing, *Thanaos martialis* (Than'a-os mar-ti-a'lis).—The wings are grayish brown with many dark brown spots evenly distributed and with several

minute white ones on the outer half of the fore wings (Fig. 453). This skipper is found throughout the greater part of the United States east of the Rocky Mountains.

Among the smaller members of this subfamily are the skippers of the genus *Pholisora*. The most widely distributed species of this genus is the Sooty-wing, *Pholisora catullus* (Phol-i-so'ra ca-tul'lus). The expanse of the wings is a little more than one inch. The wings are nearly black, marked with minute white spots, which vary in size and number. This species is found throughout the United States except along the extreme northern border.

The genus *Hesperia* includes a considerable number of small skippers, which are easily recognized by their checkered markings of white upon a dark brown ground. Small white spots on the wings are common in this subfamily, but in this genus the white spots are unusually large, so large in some cases that they occupy the greater part of the wing. One of the more common species is the Variegated Tessellate, *Hesperia montivaga* (Hes-pe'ri-a mon-tiv'a-ga). This is distributed from the Atlantic to the Pacific, and is the only one common in the Eastern United States. In this species more than one half of the outer two thirds of both fore and hind wings is white.

Subfamily PAMPHILINÆ (Pam-phi-li'næ).

Skippers with a Discal Patch.

This subfamily includes the greater number of our smaller skippers. Some of the species, however, surpass in size many of the Hesperiinæ. To the Pamphilinæ belong all of our common tawny skippers, as well as some black or dark brown species. The antennæ usually have a stout club, with a short, recurved tip; sometimes this tip is wanting. In the majority of our species the males can be recognized at a glance by a conspicuous

FIG. 454.—*Limochores pontiac*, male.

discal patch, which usually appears to the naked eye like a scorched, oblique streak near the center of each fore wing (Fig. 454). This patch is a complicated organ, composed of tubular scales that are outlets of scent-glands and other scales of various shapes. The females can be recognized by their resemblance in other respects to the males. In some species the discal patch is wanting in the males also.

This subfamily is an exceedingly difficult one to study. More than one hundred species have been described from America north of Mexico; and in many cases the differences between allied species are not well marked. The following two are named merely as examples, The first is easily recognized. But it is not worth while for the beginning student to attempt to distinguish other members of this subfamily.

The Least Skipper, *Ancyloxipha numitor* (An-cy-lox'i-pha nu'mi-tor).—This skipper is the smallest of our common species, and is also remarkable for lacking the recurved hook at the tip of the antennæ. The wings are tawny, broadly margined with dark brown. In some specimens the fore wings are almost entirely brown. The larger individuals expand about one inch. The larva feeds upon grass in damp places.

The Black Dash, *Limochores pontiac* (Li-moch'o-res pon'ti-ac).—The male of this species is represented by Figure 454. It is blackish brown, with considerable yellow on the basal half of the fore wings. The discal patch is velvety black. This species is distributed from Massachusetts to Nebraska.

Superfamily PAPILIONINA (Pa-pil-i-o-ni'na).

The Butterflies.

The butterflies differ from moths in that they have clubbed antennæ, fly only in the daytime, and hold the

wings erect above the back when at rest. There are some moths that have clubbed antennæ, and others that fly by day but no moth presents all three of the characteristics given above.

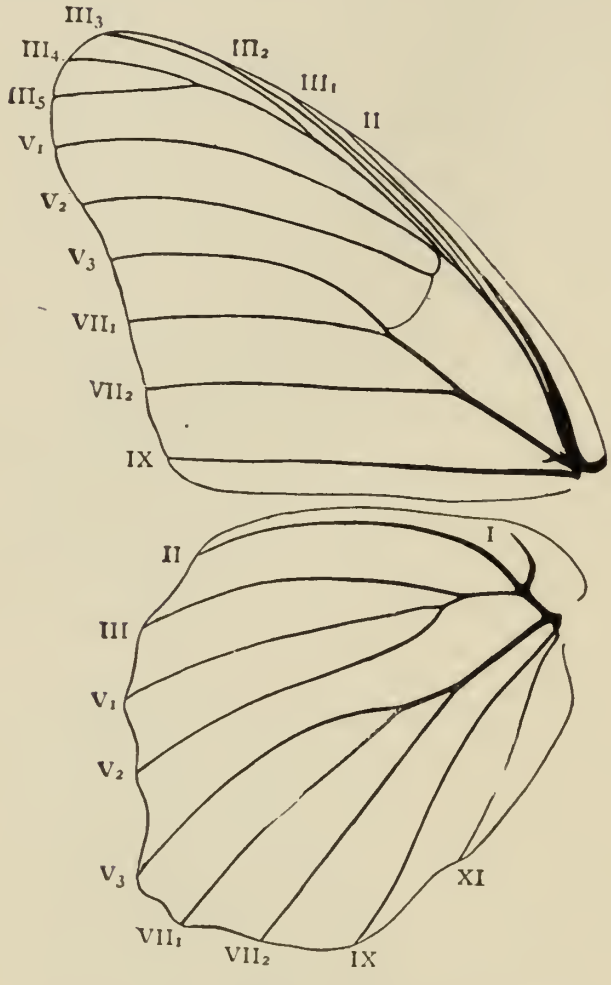


FIG. 455.—Wings of *Basilarchia astyanax*.

It is more difficult to distinguish the butterflies from the skippers; yet this can be easily done. In butterflies the club of the antenna is bluntly rounded at the tip instead of being furnished with a recurved point as in most skippers; the abdomen is very slender; and some of the branches of radius of the fore wings coalesce beyond the apex of the discal cell (Fig. 455). There are butterflies in which all of the branches of radius present arise from the discal cell; but this is due to the fact that two of the branches coalesce to the edge of the wing, as is shown by the fact that in these butterflies radius has less than five branches.

This superfamily includes four families, which can be separated as follows:—

A. Cubitus of the fore wings apparently four-branched (Fig. 456). p. 375.....PAPILIONIDÆ.

AA. Cubitus of the fore wings apparently three-branched (Fig. 455).

B. With six well-developed legs, although in some species the fore

legs of the male are a little shorter, and the tarsi of these lack one or both claws; radius of the fore wings, with rare exceptions, only three- or four-branched. To determine the number of branches of radius, count the two cubital and the three medial branches first; the branches left between veins V_1 and II belong to radius.

C. Vein V_1 of the fore wings arising at or near the apex of the discal cell (Fig. 465) except in *Feniseca tarquinius*, in which the wings are dark brown, with a large fulvous spot on each. p. 388. . . . . LYCÆNIDÆ.

CC. The first branch of media of the fore wings united with the last branch of radius for a considerable distance beyond the apex of the discal cell (Fig. 460). Ground color of wings white, yellow, or orange. p. 381 . . . . . PIERIDÆ.

BB. With only four well-developed legs, the fore legs being unused, much shorter than the others, and folded on the breast like a tippet (except in the female of *Hypatus*). Radius of fore wings five-branched (Fig. 467), p. 395 . . . . . NYMPHALIDÆ.

Family PAPILIONIDÆ (Pa-pil-i-on'i-dæ).

The Swallow-tails and the Parnassians.

This family includes the swallow-tail butterflies, which are common throughout our country, and the Parnassians, which are found only on high mountains or far north. These insects are distinguished from all other butterflies by the fact that vein V_2 of the fore wings appears to be a branch of cubitus, making this vein appear four-branched (Fig. 456), and also by the fact that the anal area of the hind wings is more reduced than the anal area of the fore wings, the former containing only a single anal vein, the latter two or three.

The caterpillars are never furnished with spines, but are either naked or clothed with a few fine hairs. In a single species in our fauna (*Laertias philenor*) the body of the larva bears fleshy filaments.

A striking peculiarity of the larvæ of this family is the presence of a pair of bright-colored fleshy "horns," which can be projected from a slit in the dorsal wall of the pro-

thorax. These have been termed *osmateria* (os-ma-te'ria), and are supposed to be organs of defence; for they exhale when pushed out an odor which in some species is exceedingly disagreeable.

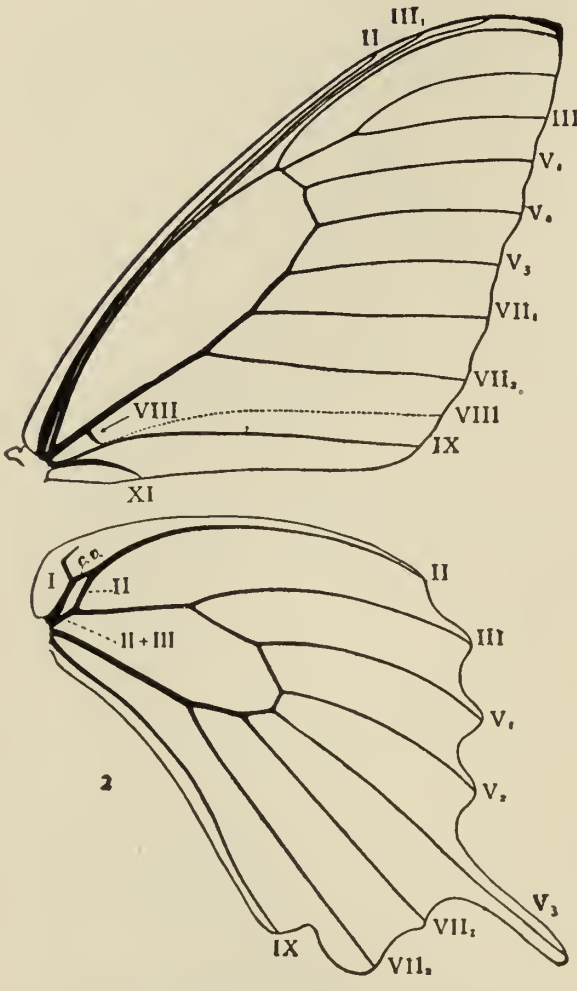


FIG. 456.—*Wings of Papilio polyxenes.*

The chrysalids are thickened in the middle and taper considerably at each end; they are more or less angulated, and have certain parts excessively produced; they are suspended by the tail and by a loose girth around the middle.

This family includes two well-marked subfamilies, which are distinguished as follows:—

A. Hind wings with a tail-like prolongation; ground-color of wings black; radius of fore wings five-branched; the base of vein VIII of fore wings preserved as a spur-like branch of vein VII (Fig. 456). p. 376 PAPILIONINÆ.

AA. Hind wings without tail-like prolongation; ground color of wings white; radius of fore wings four-branched; vein VIII of fore wings wanting. p. 380 ..... PARNASSIINÆ.

Subfamily PAPILIONINÆ (Pa-pil-i-o-ni'næ).

The Swallow-tails.

These magnificent butterflies are easily recognized by their large size and the tail-like prolongations of the hind wings. The ground color of the wings is black, which is

usually marked with yellow, and often with metallic blue or green.

There are about twenty-five species of swallow-tails in America north of Mexico. The following well-known species will serve as illustrations.

The Black Swallow-tail, *Papilio polyxenes* (Pa-pil'i-o po-lyx'e-nes).—The larva of this swallow-tail (Fig. 457) is well known to most country children. It is the green worm, ringed with black and spotted with yellow, that eats the leaves of caraway in the back yards of country houses. It feeds also on parsnip and other umbelliferous plants. These caterpillars always fascinated us in our childhood; we have spent many idle moments in poking them with straws to see them rear upward and project their yellow horns, which gave off a sickening odor. When ready to transform the caterpillar crawls away to a fence or the side of the house and changes to an angular pupa, suspended by the tail and by a little silken girth around the middle.

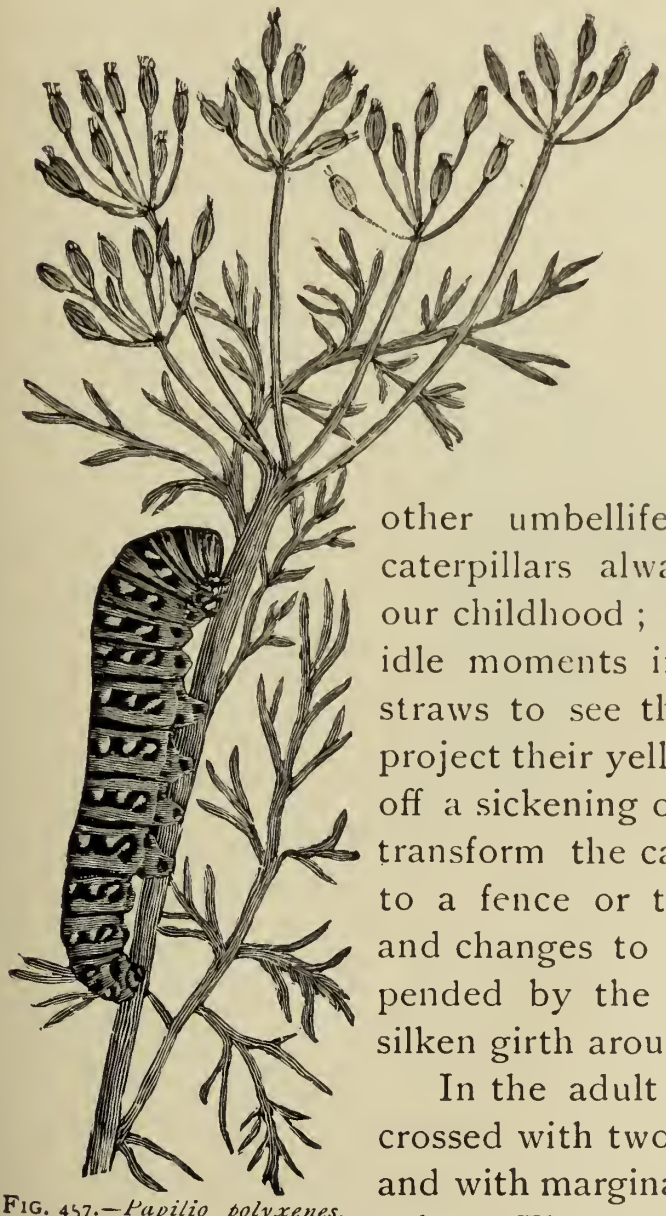


FIG. 457.—*Papilio polyxenes*, larva.

In the adult the wings are black, crossed with two rows of yellow spots, and with marginal lunules of the same color. The two rows of spots are much more distinct in the male than in the female, the inner row on the hind wing forming a continuous band crossed

with black lines on the veins. Between the two rows of spots on the hind wings there are many blue scales; these are more abundant in the female. Near the anal angle of the hind wing there is an orange spot with a black center. On the lower surface of the wings the yellow markings become mostly orange and are heavier.

This species is found throughout the United States and in the southern parts of Canada.

The Tiger Swallow-tail, *Jasoniades glaucus* (Jas-o-ni'a-des glau'cus).—The larva of this butterfly (Fig. 458) is even more striking in appearance than that of the preceding species. When full grown it is dark green, and bears on each side of the third thoracic segment a large greenish-yellow spot, edged with black, and enclosing a small purple spot bordered with black. This caterpillar has the curious habit of weaving upon a leaf a carpet of silk, upon which it rests when not feeding; when nearly full grown, instead of spinning a simple carpet as before, it stretches a web across the hollow of a leaf and thus makes a spring bed upon which it sleeps (Fig. 458).

FIG. 458.—*Jasoniades glaucus*, larva upon its bed.

In the adult state two distinct forms of this insect occur. These differ so greatly in appearance that they were long considered distinct species. They may be distinguished as follows:—

(1) The Turnus Form, *Jasoniades glaucus turnus*.—The wings are bright straw yellow above, and pale, faded straw-yellow beneath, with a very broad black outer margin, in which there is a row of yellow spots. On the fore wings there are four black bars, extending back from the costa; the inner one of these crosses the hind wings also. This form

is represented by both sexes, and is found in nearly all parts of the United States and Canada.

(2) The Glaucus Form, *Jasoniades glaucus glaucus.*—In this form the disk of the wings is entirely black, but the black bands of the Turnus form are faintly indicated, especially on the lower surface, by a darker shade. The marginal row of yellow spots is present, and also the orange spots and blue scales of the hind wings. This form is represented only by the female sex, and occurs only in the more southern part of the range of the species, i.e., from Delaware to Montana and southward.

The Zebra Swallow-tail, *Iphiclides ajax* (Iph-i-cli'des a'jax).—This butterfly (Fig. 459) differs from all other swallow-tails found in the eastern half of the United States in having the wings crossed by several bands of greenish white. This is one of the most interesting of our butterflies, as it occurs under three distinct forms, two of which were considered for a long time distinct species. Without taking into account the more minute differences these forms can be separated as follows:—

FIG. 459.—*Iphiclides ajax.*

(1) The Early-spring Form, *Iphiclides ajax marcellus* (mar-cel'lus).—This is the form figured here. It expands from two and six tenths inches to two and eight tenths inches; and the tails of the hind wings are about six tenths inch in length and tipped with white.

(2) The Late-spring Form, *Iphiclides ajax telamonides*

(tel-a-mon'i-des).—This form is a little larger than *marcellus* and has tails nearly one third longer; these tails are bordered with white on each side of the distal half or two thirds of their length.

(3) The Summer Form, *Iphiclides ajax ajax*.—The summer form is still larger, expanding from three and two tenths inches to three and one half inches, and has tails nearly two thirds longer than the early-spring form.

The life-history of this species has been carefully worked out by Mr. W. H. Edwards. He has shown that there are several generations each year, and that the winter is passed in the chrysalis state. But the early-spring form and the late-spring form are not successive broods; these are both composed of individuals that have wintered as chrysalids, those that emerge early developing into *marcellus*, and those that emerge later developing into *telamonides*. All of the butterflies produced from eggs of the same season, and there are several successive broods, are of the summer form, *ajax ajax*.

The larva feeds upon papaw (*Asimina*). This insect is found throughout the eastern half of the United States except in the extreme north.

Subfamily PARNASSIINÆ (Par-nas-si-i'næ).

The Parnassians (*Par-nas'si-ans*).

The Parnassians differ from the Swallow-tails in lacking the tail-like prolongations of the hind wings and in that the ground-color of the wings is white; but resemble them in the general plan of the venation of the wings, and in possessing similar scent-organs (osmateria) in the larval state. The wings of the butterflies are usually conspicuously marked with black spots and shades, and with red spots. Only four species have been found in North America. These belong to the genus *Parnassius* (Par-nas'si-us). They are found only on high mountains or far north.

Family PIERIDÆ (Pi-er'i-dæ).

The Pierids (*Pi'e-rids*).

These butterflies are usually of medium size, but some of them are small; they are nearly always white, yellow, or orange, and are usually marked with black. They are the most abundant of all our butterflies, being common everywhere in fields and roads. Some species are so abundant as to be serious pests, the larvæ feeding on cultivated plants.

The characteristic features of the venation of the wings are the following (Fig. 460): Vein V_2 of the fore wings is more closely connected with radius than with cubitus, the latter appearing to be three-branched; vein V_1 of the fore wings coalesces with radius for a considerable distance beyond the apex of the discal cell; and only three or four of the branches of radius remain distinct.

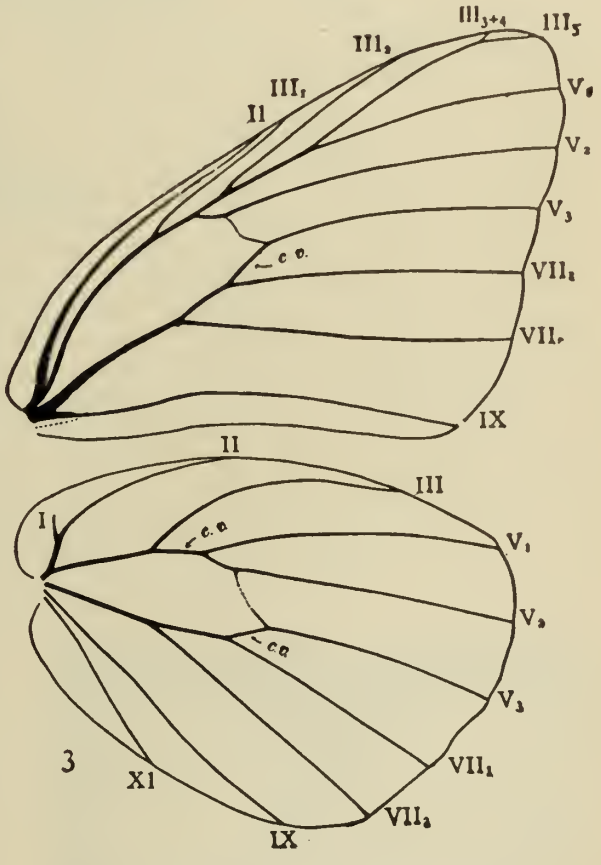


FIG. 460.—Wings of *Pontia protodice*.

In this family the fore legs are well developed in both sexes, there being no tendency to their reduction in size, as in the two following families.

The larvæ are usually slender green worms clothed with short, fine hairs; the well-known Cabbage-worms are typical illustrations (Fig. 461). The chrysalids are supported by the tail and by a loose girth around the middle. They may be distinguished at a glance by the presence of a single pointed projection in front (Fig. 461).

Our genera of this family can be separated into three groups, which seem hardly distinct enough to be ranked as

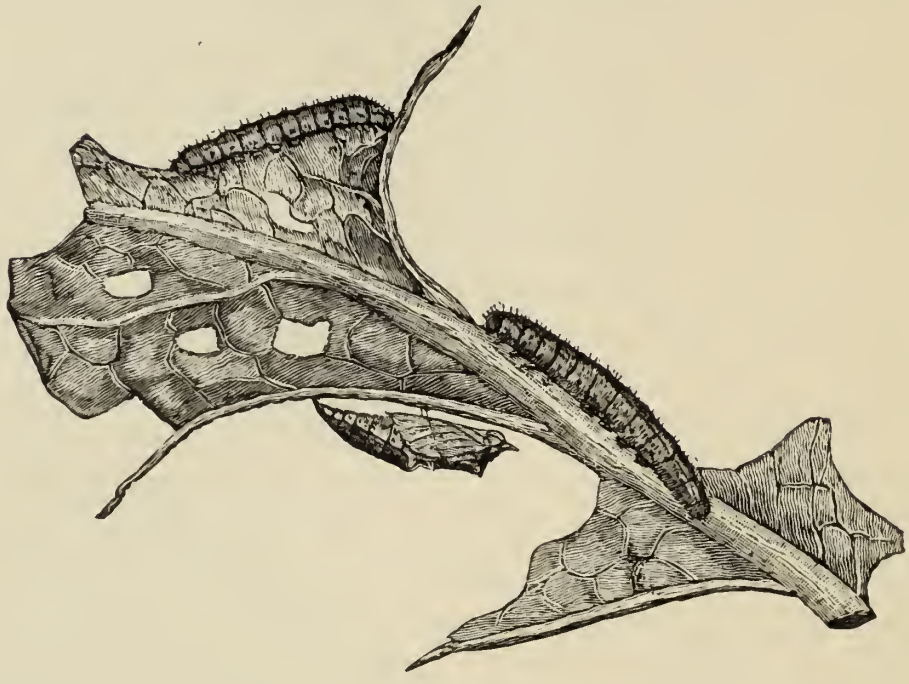


FIG. 461.—*Pieris rapæ*, larvæ and pupa.

subfamilies. These are the Whites, the Yellows, and the Orange-tips.

I. *The Whites.*—The more common representatives of this group are the well-known Cabbage-butterflies. They are white butterflies more or less marked with black. Occasionally the white is tinged with yellow; and sometimes yellow varieties of our white species occur. About a dozen North American species of this group are known.

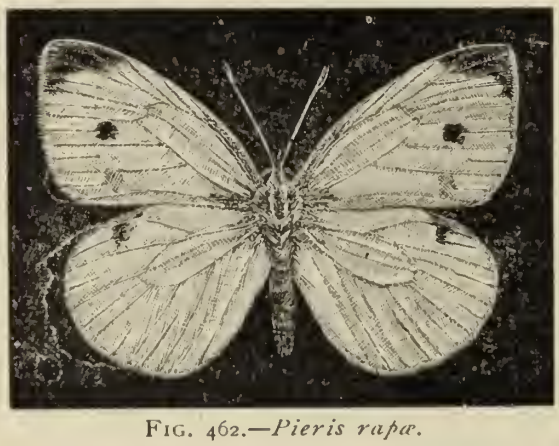


FIG. 462.—*Pieris rapæ.*

The Cabbage-butterfly, *Pieris rapæ* (Pi'e-ris ra'pæ).—The wings of this butterfly are dull white above, occasionally tinged with yellowish, especially in the female; below, the apex of the fore wings and the entire

surface of the hind wings are pale lemon-yellow. In the female there are two spots on the outer part of the fore wing besides the black tip, in the male only one (Fig. 462). There is considerable variation in the intensity of the black markings, and in the extent of the yellow tinge of the wings.

The larva of this species (Fig. 461) feeds principally on cabbage, but it also attacks many other cruciferous plants. Its color is the green of the cabbage-leaf, with a narrow, greenish, lemon-yellow dorsal band, and a narrow, interrupted stigmatal band of the same color. The body is clothed with very fine short hairs.

Pieris rapæ is without doubt the most injurious to agriculture of all our species of butterflies. It is an introduced species, but has spread over the greater part of this country. As it is three-brooded in the North and probably more in the South, it is present nearly the entire season, so that it needs to be fought constantly. Owing to the impracticability of using poison upon cabbage, and to the fact that the larva bores into the heart of the cabbage beyond the reach of applications to the plant, it is an exceedingly difficult insect to combat. Obviously it is important in fighting this insect to thoroughly subdue the spring and summer broods, so that the bulk of the fighting can be done before the cabbage begins to head. For this purpose pyrethrum and kerosene emulsion have been found most useful.

The Gray-veined White, *Pieris oleracea* (Pi'e-ris ol-e-ra'-ce-a).—The wings are white above and below, with a scarcely perceptible tinge of greenish yellow. Sometimes there is a dark spot on the fore wing between veins V_3 and VII_1, but usually the wings are unspotted. The base of the wings, however, and the basal half of the costa of the front wings, are powdered more or less with dark scales, and the veins of the wings, especially on the lower side, are grayish.

This species occurs throughout Canada and in the more

northern portions of the United States. The larva feeds on cabbage.

The Checkered White, *Pontia protodice* (Pon'ti-a prot-od'i-ce).—The two sexes of this species differ greatly in appearance, the female being much more darkly marked than the male. The wings are white, marked above with grayish brown. There is a bar of this color at the end of the discal cell; beyond this there is in the male a row of three more or less distinct spots, and in the female an almost continuous band of spots. Besides these there is in the female a row of triangular spots on the outer margin of both fore and hind wings, and on the hind wings a submarginal zigzag bar.

The larva of this species is colored with alternating stripes of bright golden yellow and dark greenish purple, upon which are numerous black spots. It feeds upon cabbage and other cruciferous plants, and occurs in nearly the whole of the United States. Both this and the preceding species seem to become greatly lessened in numbers by the increase of the imported *Pieris rapæ*.

II. *The Orange-tips.*—These, like the butterflies comprising the preceding group, are white, marked with black. Their most characteristic feature is the presence on the lower surface of the hind wings of a greenish network, or a marbled green mottling. This usually shows through the wing so as to appear as a dark shade when the wings are seen from above (Fig. 463). Many species have a conspicuous orange spot on the apical portion of the front wings. This has suggested the common name Orange-tips for the group. But it should be remembered that some species lack this mark, and that in some others it is confined to the males. Nearly all of our species are confined to the far West. The two following occur in the East.

FIG. 463.—*Synchloe olympia.*

The Falcate Orange-tip, *Anthocharis genutia* (An-thoch'-a-ris ge-nu'ti-a).—In this species the apex of the fore wings is hooked, reminding one of the Hook-tip Moths. In the males there is a large apical orange patch. This butterfly is found throughout the southeastern part of the United States, not including Florida. It occurs as far north as New Haven, Conn. It is nowhere abundant.

Synchloe olympia (Syn'chlo-e o-lym'pi-a).—In this species the orange patch is wanting in both sexes. There is a conspicuous black bar at the end of the discal cell of the fore wings, and the apical portion of these wings is gray, including a large irregular white band (Fig. 463).

This species occurs in the Mississippi Valley.

III. *The Yellows.*—The Yellows are easily recognized by their bright yellow colors, although in some species whitish forms occur. They abound almost everywhere in open fields, and are common about wet places in roads. To this group belong the larger number of our Pierids.

The Clouded Sulphur, *Eurymus philodice* (Eu'ry-mus phi-lod'i-ce).—The wings above are rather pale greenish yellow, with the outer borders blackish brown. Figure 464 represents the male; in the female the border on the fore wings is broader, and contains a submarginal row of yellow spots. The discal dot of the fore wings is black, that of the hind wings is orange. The under surface is sulphur-yellow.

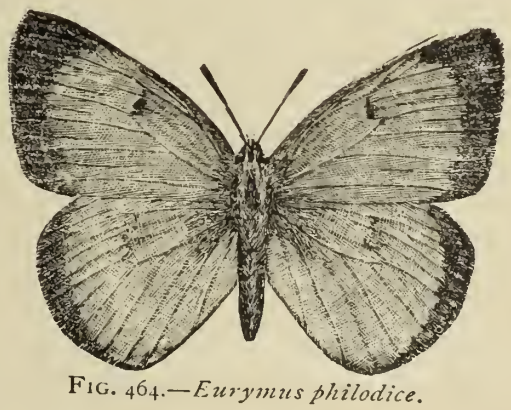


FIG. 464.—*Eurymus philodice.*

This species is dimorphic. The second form is represented only by the female sex, and differs in having the ground-color of the wings white instead of yellow.

The Clouded Sulphur occurs from the mouth of the St. Lawrence to South Carolina and westward to the Rocky Mountains. Its larva feeds upon clover and other Leguminosæ.

The Orange Sulphur, *Eurymus eurytheme* (E. euryth′e-me).—This species closely resembles *philodice* in size, shape, and markings. The typical form differs from *philodice* in being of an orange color above instead of a yellow.

The Orange Sulphur is a Western species, occurring in the Mississippi Valley and west to the Pacific Ocean. It is one of the most polymorphic of all butterflies; the forms differ so much in appearance that four or five of them have been described as distinct species. The larva feeds on clover.

The Dog's-head, *Zerene cæsonia* (Ze-re′ne cæ-so′ni-a.)—The wings are lemon-yellow above, bordered on the outer margin with black. On the hind wings the border is narrow, but on the fore wings it is broad. The outline of the yellow of the fore wings suggests a head of a dog or of a duck, a prominent black spot on the discal vein serving as the eye. This is an abundant species in the Southeastern and Southwestern States, extending from the Atlantic to the Pacific. The larva feeds on clover.

The Black-bordered Yellow, *Xanthidia nicippe* (Xanthid′i-a ni-cip′pe).—The wings above are bright orange, marked with blackish brown as follows: on the fore wings a narrow bar at the apex of the discal cell, the apical portion of the wings, and the outer margin; on the hind wings, the outer margin. In the female the outer marginal band is interrupted at the anal angle of each wing, and on the hind wings it may be reduced to an apical patch. The expanse of wings is from one and six tenths inches to one and nine tenths inches.

The species occurs from Southern New England to Florida and west to Lower California. The larva feeds on several species of Cassia.

The Little Sulphur, *Eurema lisa* (Eu-re′ma li′sa).—Although this species is larger than the following one it is considerably below the average size of our yellows, the

larger specimens expanding less than one inch and a half. The wings are canary-yellow above, with the apex of the fore wing and the outer margin of both fore and hind wings blackish brown. The border of the hind wing is narrow and sometimes wanting.

The distribution of this species is similar to that of the preceding. The larva feeds on Cassia.

The Dainty Sulphur, *Nathalis iole* (Na-tha'lis i'o-le).—This little butterfly can be distinguished from all others described here by its small size, as it expands only from less than one inch to one and one fifth inches. It is of a pale canary-yellow color, with dark brown markings. There is a large apical patch on the fore wings, and a broad band parallel with the inner margin; on the hind wings there is a stripe on the basal two thirds of the costa, and spots on the ends of the veins; these are more or less connected on the margin of the wing, especially in the female.

This species also is found from Southern New England to Florida and west to Lower California. It, too, feeds on Cassia.

The Cloudless Sulphur, *Callidryas eubule* (Cal-lid'ry-as eu-bu'le).—This large butterfly differs greatly in appearance from those described above. It expands two and one half inches. The wings above are of uniform bright canary-yellow. In the male they are without spots, except frequently an inconspicuous brown dot at the tip of each vein, and a lilac-brown edging of the costal border. In the female there is a discal dot on the fore wing and a marginal row of brown spots at the ends of the veins.

This is a southern species which occasionally extends as far north on the coast as New York City, and in the Mississippi Valley as far as Southern Wisconsin. The larva feeds on Cassia.

Family Lycænidæ (Ly-cæn'i-dæ).

The Gossamer-winged Butterflies.

The family Lycænidæ includes butterflies which are of small size and delicate structure. In size they resemble the smaller Hesperiidæ; but they can be distinguished at a glance from the skippers, as they present an entirely different appearance. The body is slender, the wings delicate and often brightly colored, and the club of the antenna straight. The antennæ are nearly always ringed with white, and a conspicuous rim of white scales encircles the eyes.

An easily-observed combination of characters by which the members of this family can be distinguished is the absence of one or two of the branches of radius of the fore wings, this vein being only three- or four-branched, and the origin of vein V_1 of the fore wings at or near the apex of the discal cell (Fig. 465). In all other butterflies occurring in our fauna in which radius is only three- or four-branched, vein V_1 of the fore wings coalesces with radius for a considerable distance beyond the apex of the discal cell. An exception to the characters of the Lycænidæ is presented by *Feniseca*, as indicated in the table of families, p. 375.

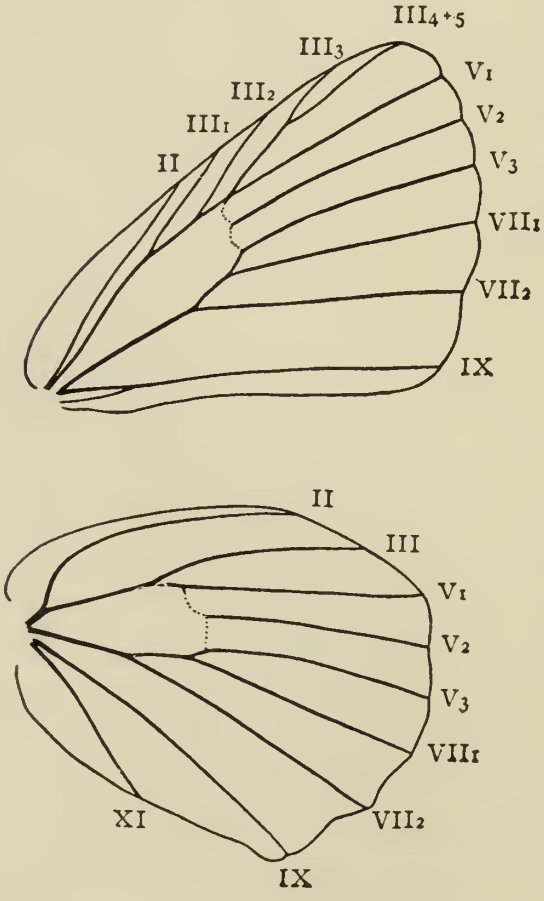


Fig. 465.—Wings of *Chrysophanus thoe.*

A remarkable characteristic of this family is that while in

PLATE VI.

the female the front legs are like the other legs, in the male they are shorter, without tarsal claws, and with the tarsi more or less aborted. This reduction of the fore legs is carried even farther in the next family, where it extends to both sexes, and the fore legs are unused.

The caterpillars of the Lycænidæ present a very unusual form, being more or less slug-like, reminding one of the larvæ of the Eucleidæ. The body is short and broad; the legs and prolegs are short and small, allowing the body to be closely pressed to the object upon which the insect is moving—in fact some of the species glide rather than creep; and the head is small, and can be retracted more or less within the prothorax. The body is armed with no conspicuous appendages; but some of the species are remarkable for having honey-tubes which can be pushed out from the seventh and eighth abdominal segments, and through which honey-dew is excreted for the use of ants. Certain other species are remarkable in being carnivorous; one American species feeds exclusively upon plant-lice.

The chrysalids are short, broad, ovate, and without angulations. They are attached by the caudal extremity, and by a loop passing over the body near its middle. The ventral aspect of the body is straight and often closely pressed to the object to which the chrysalis is attached.

The Lycænidæ include two subfamilies; these can be be separated as follows:—

A. Vein II of the hind wings without a branch near the base of the wing (Fig. 465)..... .....LYCÆNINÆ.

AA. Vein II of the hind wings giving off a spur (the tip of vein I) near the base of the wing. p. 394.....LEMONIINÆ.

Subfamily LYCÆNINÆ (Ly-cæ-ni'næ).

The Common Gossamer-winged Butterflies.

This subfamily includes all of our common members of the Lycænidæ; it is composed of three well-marked groups

of genera, which have been distinguished as the Coppers, the Blues, and the Hair-streaks.

I. *The Coppers.*—The Coppers are easily distinguished from other gossamer-winged butterflies by their orange-red and brown colors, each with a coppery tinge, and conspicuous black markings. They are the stoutest of the Lycænidæ. About twenty species are known to occur in this country; the three following will serve as illustrations:—

The American Copper, *Heodes hypophlæas* (He-o'des hyp-o-phlæ'as).—This is the most common of our coppers in the Northeastern States and in Canada. Its range extends also along the boundary between the United States and Canada to the Pacific Ocean, and southward into California; and in the east along the Alleghany Mountains south to Georgia. It is represented on Plate I (Fig. 5). The fore wings are orange-red above, spotted with black, and with a blackish brown outer border; the hind wings are coppery brown, with a broad orange-red band on the outer margin; this band is indented by four black spots.

The larva feeds on the common sorrel (*Rumex acetosella*).

The Bronze Copper, *Chrysophanus thoe* (Chrys-o-pha'nus tho'e).—This is larger than the preceding species, the wings expanding one and one half inches or more. In the male the wings are coppery brown above, spotted with black, and with a broad orange-red band on the outer margin of the hind wings. The female differs in having the fore wings orange-red above, with prominent black spots.

This species occurs in the Middle and Western States from the Connecticut Valley to Nebraska. The larva feeds on curled dock (*Rumex crispus*).

The Wanderer, *Feniseca tarquinius* (Fe-nis'e-ca tar-quin'i-us).—This butterfly can be readily distinguished from all other Lycænids in our fauna by the fact that vein V_1 of the fore wings coalesces with radius for a considerable distance beyond the apex of the discal cell. The upper surface of the wings is dark brown, with a large, irregular, orange-

yellow patch on the disk of the fore wing, and one of the same color next the anal angle of the hind wing.

This species is of unusual interest, as the larva is carnivorous in its habits. It feeds on plant-lice; and, so far as observed, it feeds only on the woolly aphids. It is found more often in colonies of the Alder Blight (*Schizoneura tessellata*) than in those of the allied species. It is found from Maine to Northern Florida and westward to Kansas. It is a very local insect, being found only in the neighborhood of water where alder grows.

II. *The Blues.*—The Blues may be distinguished from the other gossamer-winged butterflies by the slender form of the body, and the blue color of the upper surface of the wings. About fifty North American species have been described; but most of these occur only in the far West. This is a rather difficult group to study owing to the fact that in several cases a single species exists under two or more distinct forms, and also that the two sexes of the same species may differ greatly. It often happens that two individuals of the same sex but of different species resemble each other more closely in the coloring of the upper surface than do the two sexes of either of the species. In each of our eastern species the upper surface of the wings of the female is much darker than that of the male.

The Spring Azure, *Cyaniris pseudargiolus* (Cy-a-ni′ris pseud-ar-gi′o-lus).—In this species the hind wings are without tails, the eyes are hairy, and the lower surface of the wings is pale ash-gray. This combination of characters will distinguish it from all other blues occurring in the Eastern United States. But the species is not confined to this region, as it occurs in nearly all parts of the United States and in a large part of Canada.

This butterfly exhibits polymorphism to the greatest degree of any known species; nine or ten forms have been described. Two of these are represented on Plate VI (Figs. 1 and 7).

The larva feeds on the buds and flowers of various

plants, especially those of *Cornus*, *Cimicifuga*, and *Actinomeris*. They are frequently attended by ants for the sake of the honey-dew which they excrete through tubes that they push out from the seventh and eighth abdominal segments.

The Tailed Blue, *Everes comyntas* (E-ve'res co-myn'tas).—The butterflies of the genus *Everes* can be distinguished from our other blues by the presence of a small tail-like prolongation of the hind wing. This is borne at the end of vein VII. Our common species (*E. comyntas*) is distributed over nearly all parts of North America. The male is dark purplish violet above, bordered with brown; the female is dark brown, sometimes flecked with bluish scales. In the Eastern United States this is the only species of the genus.

The larva feeds upon clover and other leguminous plants.

III. *The Hair-streaks.*—The Hair-streaks are distinguished from the other Lycæninæ by the fact that radius of the fore wings is only three-branched. They are usually dark brown, with delicate striped markings on the lower surface of the wings, which suggested the common name given above; but some species are brilliantly marked with metallic blue or green. The hind wings are also commonly furnished with delicate tail-like prolongations (Fig. 466). The fore wings of the male often bear a small dull oval spot near the middle of the costal part of the wing, the discal stigma, which is filled with the peculiar scent-scales known as andriconia. The males are also distinguished by having a tuft of hair-like scales, the beard, on the front; this is wanting or very thin in the females. About fifty species occur in America north of Mexico; of these nearly twenty occur in the eastern half of the United States.

FIG. 466.—*Thecla calanus.*

The Banded Hair-streak, *Thecla calanus* (Thec'la cal'a-

nus).—In the Northeastern United States the most common of the hair-streaks is this species (Fig. 466). The upper surface of the wings is dark brown or blackish brown. The under surface is blackish slate-brown nearly as dark as the upper surface, and marked as shown in the figure.

The larva feeds on oak and hickory. Excepting the southern portion of the Gulf States, the species is found throughout our territory east of the Rocky Mountains, and in the southern part of Canada.

The Olive Hair-streak, *Mitoura damon* (Mi-tou'ra da'mon).—The upper surface of the wings is dark brown, with the disk more or less deeply suffused with brassy yellow in the male or tawny in the female; the hind wing has two tails, one much longer than the other, both black tipped with white. The lower surface of the hind wings is deep green; both fore and hind wings are marked with white bars bordered with brown (Plate VI, Fig. 6).

The larva feeds on red cedar. The species occurs from Massachusetts to Florida and westward to Dakota and Texas.

The Banded Elfin, *Incisalia niphon* (In-ci-sa'li-a ni'phon).—In the butterflies of the genus *Incisalia* the fringe of the outer margin of the hind wings is slightly prolonged at the end of each vein, giving the wings a scalloped outline; they also lack tail-like prolongations of the hind wings. There are several species occurring on both sides of the continent. One of these, the Banded Elfin, is represented on Plate VI (Fig. 4). In this species there is a distinct white or whitish edging near the base of the under side of the hind wing which limits a darker band that occupies the outer two thirds of the basal half of the wing.

This species occurs in the Eastern and Middle States. The larva feeds on pine.

The Hair-streaks described above are of moderate size and modest colors. The two following will serve to illustrate a somewhat different type.

The Great Purple Hair-streak, *Atlides halesus* (At'li-des

ha-le'sus).—This is the largest of our eastern hair-streaks, the larger individuals expanding two inches. In the male the greater part of the upper surface of the wings is bright blue; the discal stigma, the outer fourth of the fore wings, the apex of the inner margin of the hind wings, and the tails are black. In the female the outer half of the wings is black.

The species occurs in the southern half of the United States and southward. It has been found as far north as Illinois. The larva is said to feed on oak.

The White-M Hair-streak, *Eupsyche m-album* (Eu-psy'-che m-al'bum).—This is a smaller species, expanding about one and one half inches. The upper surface of the disk of the wings is a rich, glossy dark blue, with green reflections; a broad outer border and costal margin are black. The hind wing has two tails, and a bright dark orange spot preceded by white at the anal angle. The under surface is brownish gray, and on this surface both wings are crossed by a common, narrow white stripe, which forms a large W or reversed M on the hind wings.

This species occurs in the southern half of the United States. The larva feeds on oak and on *Astrangulus.*

Subfamily LEMONIINÆ (Le-mon-i-i'næ).

The Lemoniids (*Le-mo'ni-ids*).

This is a large subfamily; but the species are found chiefly in South and Central America. In our fauna it is represented only by a small number of rare butterflies.

If we except one Floridian species (*Eumenia atala*), this subfamily is represented in the Eastern United States by only two species. In the far West eleven others are now known. The eastern species are the Large Metal-mark, *Calephelis borealis* (Cal-e-phe'lis bo-re-a'lis), which expands one inch or more, and the Small Metal-mark, *Calephelis cænius* (C. cæ'ni-us), which expands less than four fifths of an inch. In both species there are on the outer half of the wings two lines of shining lead-colored scales.

Family NYMPHALIDÆ (Nym-phal'i-dæ).

The Four-footed Butterflies.

The family Nymphalidæ includes chiefly butterflies of medium or large size; but a few of the species are small. With a single exception, these butterflies differ from all others in our fauna in having the fore legs very greatly reduced in size *in both sexes*. So great is the reduction that these legs cannot be used for walking, but are folded on the breast like a tippet. A slight reduction in the size of the fore legs occurs in the Lycænidæ, but there it occurs only in the males, and to a much less degree than in this family.

In the venation of the wings (Fig. 467) the four-footed butterflies differ from the two preceding families in retaining all of the branches of radius of the fore wings, this vein being five-branched.

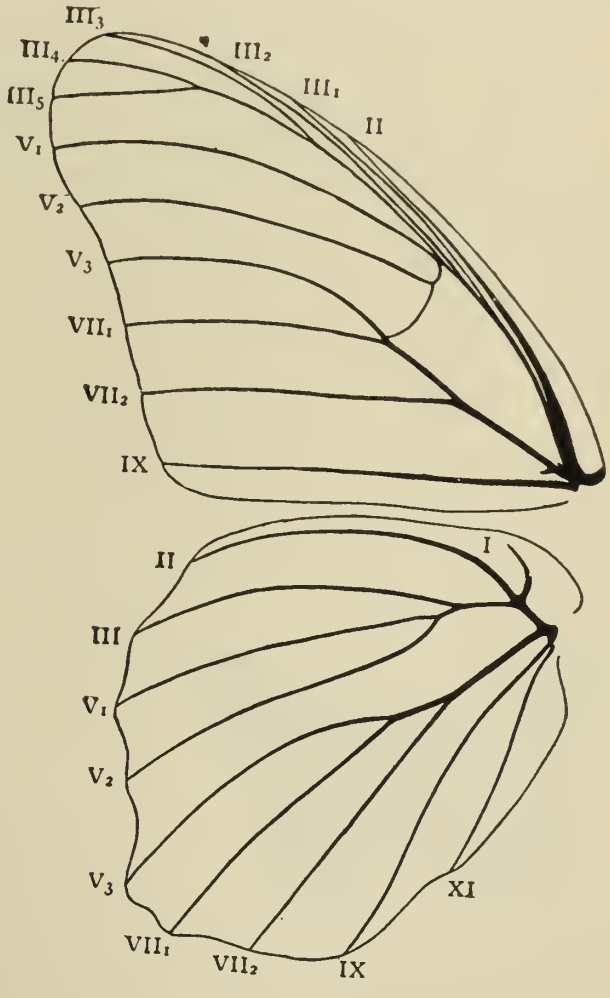


FIG. 467.—Wings of *Basilarchia astyanax*.

The larvæ are nearly or quite cylindrical, and are clothed to a greater or less extent with hairs and sometimes with branching spines.

The chrysalids are usually angular, and often bear large projecting prominences; sometimes they are rounded. They always hang head downwards, supported only by the tail, which is fastened to a button of silk.

This is the largest of the families of butterflies. It not only surpasses the other families in number of species, but it contains a greater number and variety of striking forms, and also a larger proportion of the species of butterflies familiar to every observer of insects. There may be in any locality one or two species of yellows or of whites more abundant, but the larger number of species commonly observed are four-footed butterflies.

Five subfamilies of the Nymphalidæ are represented in our fauna. These can be separated by the following table, which is based on one given by Mr. Scudder :—

A. With none of the veins of the fore wings unusually swollen at the base.
  B. Antennæ clothed with scales, at least above.
    C. Fore wings at least twice as long as broad. p. 397. HELICONINÆ.
    CC. Fore wings less than twice as long as broad.
      D. Palpi much longer than the thorax. p. 396. . LIBYTHEINÆ.
      DD. Palpi not as long as the thorax. p. 398 . . . NYMPHALINÆ.
  BB. Antennæ naked. p. 397 . . . . . EUPLŒINÆ.
AA. With some of the veins of the fore wings greatly swollen at the base. p. 410 . . . . . SATYRINÆ.

Subfamily LIBYTHEINÆ (Li-byth-e-i′næ).

The Long-beaks.

The Long-beaks can be easily recognized by their excessively long, beak-like palpi, which are from one fourth to one half as long as the body and project straight forward (Fig. 468). The outer margin of the fore wings is deeply notched; the males have only four well-developed legs, while the females have six.

FIG. 468.—*Hypatus bachmanni.*

Only three species have been found in America north of Mexico; and of these but one occurs in the Eastern United States.

The Snout Butterfly, *Hypatus bachmannii* (Hyp'a-tus bach-man'ni-i). — The wings are blackish brown above, marked with orange patches and white spots. The species occurs throughout the Eastern United States, excepting the northern part of New England and the southern part of Florida. The larva feeds on *Celtis occidentalis.*

Subfamily HELICONIINÆ (Hel-i-co-ni-i'næ).
The Heliconians (*Hel-i-co'ni-ans*).

This subfamily consists chiefly of tropical butterflies ; a few species, however, extend into the southern portion of our territory. They are of medium or rather large size, and are easily recognized by their narrow and elongated fore wings, which are usually more than twice as long as broad.

Subfamily EUPLŒINÆ (Eu-plœ-i'næ).
The Euplœids (*Eu-plœ'ids*).

These are butterflies of large size, with rounded and somewhat elongated wings, the apical portion of the fore wings being much produced. The absence of scales on the antennæ is the most available character for distinguishing these insects. Only a very few species occur in our fauna. The best known of these is the following :—

The Monarch, *Anosia plexippus* (A-no'si-a plex-ip'pus).— The upper surface of the wings is light tawny brown, with the borders and veins black, and with two rows of white spots on the costal and outer borders as shown in Figure 469. The figure represents a female ; in the male the veins of the wings are more narrowly margined with black, and there is a black pouch next to vein VII_2 of the hind wings, containing scent-scales or androconia.

The larva feeds upon different species of milk-weed, *Asclepias.* When full grown it is lemon or greenish yellow, broadly banded with shining black. It is remarkable for bearing a pair of long fleshy filaments on the second thoracic segment, and a similar pair on the seventh abdominal seg-

ment. The chrysalis is about one inch in length. It is bright green, dotted with gold.

This species occurs throughout the greater part of the United States, and is distributed far beyond our borders.

FIG. 469.—*Anosia plexippus*.

It is believed, however, that the species dies out each year in a large part of the Northern States, and that those butterflies which appear first in this region, in June or July, have flown hither from the South, where they hibernate in the adult state. In the extreme South they fly all winter. Great swarms, including many thousands of individuals of this species, are sometimes seen.

Subfamily NYMPHALINÆ (Nym-pha-li'næ).

The Typical Nymphalids (*Nym-pha'lids*).

The butterflies of this subfamily vary so much in the outline and ornamentation of the wings that it is impossible to briefly characterize them. The student, however, will have no difficulty in distinguishing them by means of the table of subfamilies already given. Our genera represent five quite distinct groups, as follows:—

I. *The Crescent-spots or the Melitæids* (Mel-i-tæ'ids).—This group includes some of the smaller members of the Nym-

phalinæ. The color of the wings is sometimes black, with red and yellow spots; but it is usually fulvous, with the fore wings broadly margined, especially at the apex, with black, and crossed by many irregular lines of black. About fifty species occur in this country.

The Baltimore, *Euphydryas phaeton* (Eu-phyd′ry-as pha′-e-ton).—The wings above are black, with an outer marginal row of dark reddish-orange spots, and parallel rows of very pale yellow spots; on the fore wings a third row is more or less represented. The wings expand two inches or more.

The larvæ feed on a species of snakehead (*Chelone glabra*); they are gregarious, and build a common nest by weaving together the leaves of their food-plant. The species occurs in Ontario and the northern half of the United States east of the Rocky Mountains. It is very local, the butterflies remaining near the bogs or moist meadows where the food-plant of the larva is found.

The butterflies of the genus *Phyciodes* (Phy-ci-o′des) and the allied genera abound throughout our country. They are of small size, and of a fulvous color, heavily marked with black. Each species varies considerably in markings, and different species resemble each other quite closely, making this a difficult group for the beginning student. Figure 470 represents a common species.

FIG. 470.—*Phyciodes nycteis.*

II. *The Fritillaries* (Frit′il-la-ries) *or the Argynnids* (Ar-gyn′nids).—This group includes butterflies varying from a little below to somewhat above medium size. The color of the wings is fulvous, bordered and checkered with black, but not so heavily bordered as in the crescent-spots. The lower surface of the hind wings is often marked with curving rows of silvery spots. This is a large group containing many species, which are extremely difficult to separate. More than fifty species occur in America north of Mexico. The larvæ feed upon the leaves of violets.

The Great Spangled Fritillary, *Argynnis cybele* (Ar-gyn'-nis cyb'e-le).—This species (Fig. 471) will serve to illustrate

FIG. 471.—*Argynnis cybele.*

the appearance of the larger members of this group, those belonging to the genus *Argynnis*. In this genus vein III_2 of the fore wings arises before the apex of the discal cell.

There are a number of common fritillaries which resemble the preceding in color and markings but which are much smaller, the wings expanding considerably less than two inches. These belong to the genus *Brenthis* (Bren'this). In this genus vein III_2 of the fore wings arises beyond the apex of the discal cell.

The Variegated Fritillary, *Euptoieta claudia* (Eup-toi-e'ta clau'di-a).—This butterfly agrees with the smaller fritillaries (*Brenthis*) in the origin of vein III_2 of the fore wing beyond the apex of the discal cell, but differs from them in the shape of the fore wing, the apex of which is much more produced (Fig. 472), and the outer margin, except at the apex, concave; it is also considerably larger.

FIG. 472.—*Euptoieta claudia.*

This species occurs throughout the United States east of

the Rocky Mountains; but it is very rare in the northern half of this region.

III. *The Angle-wings or the Vanessids* (Va-nes'sids).—To this group belong many of our best-known butterflies. With these the outer margin of the fore wings is usually decidedly angular or notched as if a part had been cut away. A large proportion of the species hibernate in the adult state, and some of them are the first butterflies to appear in the spring. Some of the hibernating species, however, remain in concealment till quite late in the season.

The Red Admiral, *Vanessa atalanta* (Va-nes'sa at-a-lan'ta).—The wings are purplish black above. On the fore wing there is a bright orange-colored band beginning near the middle of the costa, and extending nearly to the inner angle; between this and the apex of the wing are several white spots, as shown in Figure 473; on the hind wing there is an orange band on the outer margin inclosing a row of black spots. The lower surface of the wings is shown on Plate I, Fig. 6.

FIG. 473.—*Vanessa atalanta.*

The larva feeds chiefly on nettle and on hop. When first hatched it folds together a half-opened leaf at the summit of the plant; when larger it makes its nest of a lower expanded leaf. There are two broods; both butterflies and chrysalids hibernate. This butterfly occurs over nearly the whole of the European and North American continents.

The Painted Beauty, *Vanessa huntera* (Va-nes'sa hun'-te-ra) —The wings above are very dark brownish black, with large irregular spots of golden orange. In the apical portion of the fore wings there are several white spots, as shown

in Figure 474. The lower surface of the wings is represented on Plate I, Fig. 7. A characteristic feature is the presence of *two* submarginal eye-like spots on the hind wing.

The larva feeds on everlasting (*Gnaphalium*) and allied plants. The species occurs in Ontario and nearly the whole of the United States.

FIG. 474.—*Vanessa huntera.*

The Cosmopolitan Butterfly, *Vanessa cardui* (V. car'dŭ-i).—The butterfly resembles the preceding very closely in color and markings. There is, however, a smaller proportion of orange markings; and on the lower surface of the hind wings there is a submarginal row of four or five eye-like spots.

The larva feeds upon Compositæ, especially thistles. This species is very remarkable for its wide distribution. Mr. Scudder states that "with the exception of the arctic regions and South America it is distributed over the entire extent of every continent."

FIG. 475.—*Aglais milberti.*

The American Tortoise-shell, *Aglais milberti* (Ag'la-is mil-ber'ti).—The wings above are brownish black, with a broad orange-fulvous band between the middle and the outer margin.

There are two fulvous spots in the discal-cell of the front wing (Fig. 475).

The larvæ feed upon nettle (*Urtica*); they are gregarious in their early stages. This species occurs in the northern portions of the United States and in Canada.

The Mourning-cloak, *Euvanessa antiopa* (Eu-va-nes'sa an-ti'o-pa).—The wings above are purplish brown, with a broad yellow border on the outer margin sprinkled with brown, and a submarginal row of blue spots. The upper surface is represented by Figure 476, the lower by Plate VI, Fig. 5.

The larvæ live on willow, elm, poplar, and *Celtis;* they are gregarious, and often strip large branches of their leaves. The species is usually two-brooded. "This butter-

FIG. 476.—*Euvanessa antiopa.*

fly is apparently distributed over the entire breadth of the Northern Hemisphere below the Arctic Circle as far as the thirtieth parallel of latitude" (Scudder).

The Compton Tortoise, *Eugonia j-album* (Eu-go'ni-a j-al'-bum).—This butterfly (Fig. 477) resembles in its general appearance those of the genus *Polygonia*, but it is sharply distinguished from them by the inner margin of the fore wings being nearly straight, by the heavier markings of the fore

wings, and by the presence of a whitish spot on both fore and hind wings, near the apex, and between two larger black patches. On the lower surface of the hind wings there is a small L-shaped silvery bar. This species occurs

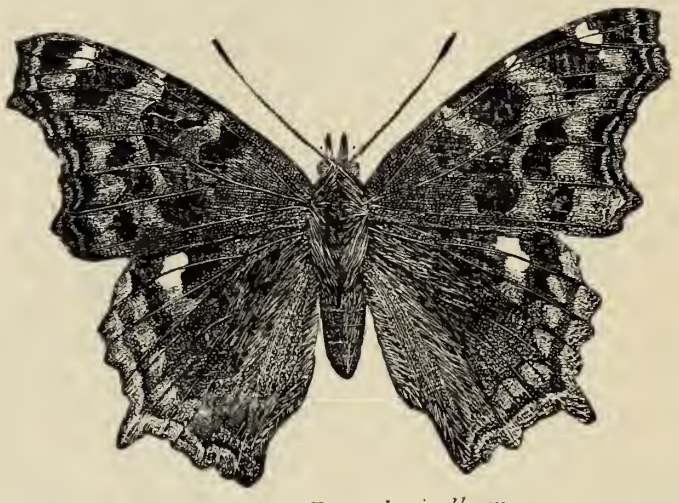


FIG. 477.—*Eugonia j-album.*

throughout Canada and the northern portion of the United States east of the Rocky Mountains.

Polygonia (Pol-y-go′ni-a).—The butterflies of this genus resemble the preceding species in having a metallic spot on the lower surface of the hind wings, but differ in having the inner margin of the fore wings roundly notched beyond the middle. Nearly a dozen species occur in this country. These differ principally in the coloring and markings of the under surface of the hind wings. The following are some of the more common ones :—

The Green Comma, *Polygonia faunus* (P. fau′nus).—The silvery mark of the hind wings is usually in the form of a C or a G, the ends being more or less expanded (Plate VI, Fig. 2), but sometimes it is reduced to the form of an L. The lower surface of the wings is more greatly variegated than in any other species of this genus ; and there is a larger amount of green on this surface than in any other of the eastern species, there being two nearly complete rows of green spots on the outer third of each wing.

The larva feeds upon black birch, willow, currant, and

wild gooseberry. This is a Canadian species; but it is also found in the mountains of New England and of New York, and in the northern portions of the Western States, extending as far south as Iowa.

The Hop-merchant, *Polygonia comma* (P. com'ma).—As in the preceding species, the silvery mark of the hind wings is in the form of a C or a G (Pl. VI, Fig. 3); but the general color of the lower surface of the hind wings is very different, being marbled with light and dark brown; and the green spots so characteristic of *faunus* are represented here by a few liliaceous scales on a submarginal row of black spots.

Two forms of this species occur. In one, *P. comma dryas*, the hind wings above are suffused with black on the outer half, so that the submarginal row of fulvous spots is obscured, and on the lower side the wings are more yellowish than in the other form. The latter is known as *P. comma harrisii* (P. c. har-ris'i-i).

The larva feeds upon hop, elm, nettle, and false-nettle. It is often abundant in hop-yards, and the chrysalids are commonly known as hop-merchants, from a saying that the golden or silvery color of the metallic spots on the back of the chrysalis indicates whether the price of hops is to be high or low. This species is found in Canada and the northern part of the eastern half of the United States; its range extends south to North Carolina, Tennessee, Arkansas, and Indian Territory.

The Gray Comma, *Polygonia progne* (P. prog'ne).—In its general appearance this butterfly closely resembles *P. comma*, but it can be readily distinguished by the form of the silvery mark, which is L-shaped and tapers towards the ends.

The larva feeds on currant, wild gooseberry, and rarely elm. This species occurs in Canada and in the northern portion of the United States except in the extreme West.

The Violet Tip, *Polygonia interrogationis* (P. in-ter-

ro-ga-ti-o′nis).—This butterfly (Plate VI, Fig. 8) is somewhat larger than the preceding species of *Polygonia*, and differs in the form of the silvery mark, which consists of a dot and a crescent, resembling somewhat an interrogation-mark, but more nearly a semicolon. On the upper side the outer margins of the wings and the tails of the hind wings are tinged with violet.

This species is dimorphic; and the two forms differ so constantly and in such a marked manner that they were described as distinct species. In *P. interrogationis fabricii* (P. i. fa-bric′i-i) the upper surface of the hind wings is not much darker than that of the fore wings, and there is a submarginal row of fulvous spots in the broad ferruginous brown border. In *P. interrogationis umbrosa* (P. i. um-bro′sa) the outer two thirds of the upper surface of the hind wings is blackish, and the submarginal fulvous spots are obliterated, except sometimes faint traces near the costal margin.

This species is found in Canada and throughout the United States east of the Rocky Mountains.

IV. *The Sovereigns.*—These butterflies differ from other Nymphalinæ in having the club of the antennæ marked by four slightly elevated lines, and in that veins I, II, and III of the hind wing (Fig. 467, p. 395) separate at the same point. This group includes some of our most elegant butterflies; the larvæ are grotesque in appearance, being very irregular in form and strikingly mottled or spotted.

The Banded Purple, *Basilarchia arthemis* (Bas-i-lar′chi-a ar′the-mis).—The upper surface of the wings is velvety chocolate-black, marked with a conspicuous white bow (Fig. 478).

This is a Canadian species which extends a short distance into the northern part of the United States; the larva feeds on birch, willow, poplar, and many other plants.

The Red Spotted Purple, *Basilarchia astyanax* (B. as-ty′a-nax).—The upper surface of the wings is velvety indigo-black, tinged with blue or green. There are three

rows of blue or green spots on the outer third of the hind wings: the spots of the inner row vary greatly in width in different individuals. On the lower surface there is a reddish orange spot in the discal cell of the fore wings, and one on the discal vein; on the hind wings there are two orange spots similarly situated, a third at the base of cell II, and a row of

FIG. 478.—*Basilarchia arthemis.*

seven spots just within a double row of submarginal blue or green spots.

This species occurs throughout nearly the whole of the Eastern United States south of the 43d parallel of latitude. The larva feeds on many plants; among them are plum, apple, pear, and gooseberry.

The Hybrid Purple, *Basilarchia astyanax-arthemis.*—There occurs, along a narrow belt of country extending from southern Wisconsin and northern Illinois eastward to the Atlantic coast of New England, a butterfly that closely resembles the Red-spotted Purple, but which has more or less of the white band of the Banded Purple. This is believed to be a hybrid between these two species. The region in which it occurs is that in which the ranges of the two species overlap. North of this region, of these three forms only the Banded Purple occurs; south of it only the Red-spotted Purple is found.

The Viceroy, *Basilarchia archippus* (B. ar-chip'pus).—The wings vary in color from a dull yellow orange tinged

slightly with brown to a dark cinnamon color; they are bordered with black, and all the veins are edged with the same color (Fig. 479). The fringe of the wings is spotted with white, and the black border on the outer margin contains a row of white spots.

FIG. 479.—*Basilarchia archippus.*

This species is remarkable for its resemblance to the Monarch (*Anosia plexippus*, Fig. 469). But aside from the structural characters separating the two subfamilies which these butterflies represent, the Viceroy can be easily distinguished from the species it mimics by its smaller size, and by the presence of a transverse black band on the hind wings.

It is believed that the resemblance of these two species is not merely accidental, but is a result of the action of the law of natural selection. The butterflies of the subfamily to which the Monarch belongs (*Euplœinæ*) are exempt from the attacks of birds. It is supposed that this exemption is due to the possession by these butterflies of a disagreeable odor. With such an odor the conspicuous coloring of the butterflies is protective, the birds soon learning that such butterflies are not fit for food. And it can be seen that these birds will naturally leave undisturbed any other butterflies

that resemble the ill-smelling ones, even though they do not possess a similar odor. According to the theory of natural selection these resemblances have been produced as follows. In the case of a variable species that is unprotected by any disagreeable quality, any variation towards a protected species will tend to preserve the life of the individual possessing it. And in turn such offspring of these individuals as still more nearly resemble the protected species will be most likely to be preserved. The continued action of this natural selection will result in producing a species that closely resembles the protected one, even though it may be very different structurally from the one that it mimics.

Many instances of unconscious mimicry of this kind are known. They are especially abundant in the tropics where the foul-smelling *Heliconinæ* are most abundant. The bad odor of these butterflies when living is so marked that it can be detected by the human nose; and it is found that many species of them are mimicked by other butterflies, and especially those of the Pieridæ. The mimicry is not confined to similarity in coloring, but extends to the shape of the wings and manner of flight.

The larva of the Viceroy feeds upon willow, poplar, balm of gilead, aspen, and cottonwood. The species two- or three-brooded, and hibernates as a partially grown larva in a nest made of a rolled leaf. This nest is lined with silk, and the leaf is fastened to the twig with silk so that it cannot fall during the winter. Mr. Scudder states that so far as is known to him all of the species of the Sovereigns hibernate as larvæ in nests of this kind. It is worthy of note that only the autumn brood of caterpillars make these nests. So that the nest-building instinct appears only in alternate generations, or even less frequently when the species is more than two-brooded. *B. archippus* is found over nearly the whole of the United States as far west as the Sierra Nevada Mountains, and has been found sparingly even to the Pacific coast near our northern boundaries.

As *Anosia plexippus* has been termed the Monarch, this species is aptly called the Viceroy.

V. *The Emperors.*—The butterflies of this group are found chiefly in the southern part of our country. The following is the best known species:—

The Goat-weed Butterfly, *Anæa andria* (A-næ'a an'-dri-a).—The female of this species can be easily recognized by Figure 480. The male is smaller, with wings of a rich

FIG. 480.—*Anæa andria.*

dark orange, margined with brown, and without the light-colored band characteristic of the female.

This species is found in the Western States from Illinois to Texas. The larva feeds on goat-weed (*Croton*).

Subfamily SATYRINÆ (Sat-y-ri'næ).

The Meadow-browns or Satyrs.

This subfamily includes chiefly brown butterflies whose markings consist almost entirely of eye-like spots. Some western species, however, are bright-colored. Our forms can be easily recognized by their having some of the veins of the fore wings greatly swollen at the base.

The larvæ are cylindrical, tapering more or less towards each end. The caudal segment is bifurcated, a character that distinguishes them from all other American butterfly

larvæ excepting those of some of the Emperors (*Chlorippe*), not described in this book. Nearly sixty species belonging to this subfamily have been described from America north of Mexico.

The Eyed Brown, *Satyrodes eurydice* (Sat-y-ro′des eu-ryd′i-ce).—The upper surface of the wings is soft mouse-brown on the basal half and paler beyond, considerably so in the female; each wing bears a row of four or five small black eye-like spots (Fig. 481). This species is found in Ontario, and throughout the eastern half of the United States.

FIG. 481.—*Satyrodes eurydice.*

The Dull-eyed Grayling, *Cercyonis nephele* (Cer-cy′o-nis neph′e-le).—The two most conspicuous of the Meadow-browns that occur east of the Rocky Mountains are this and the following one; they are comparatively large species, expanding from two inches to two and one fourth inches; both are dark brown. In this species there are on the upper surface of the fore wing on the outer third of the wing two black spots with white or bluish centers; sometimes the wing is tinged with yellow in the vicinity of these spots, but generally the tinge is very slight, and it is never so deep as in the next species; the hind wing is with or without a spot in cell VII_1, and sometimes with a spot on either side of this one. On the lower surface the eye-like spots of the fore wings are distinctly ringed with yellowish; and the hind wings are with or without eye-like spots, usually with six of them. (See the Hybrid Graylings, below.)

The Blue-eyed Grayling, *Cercyonis alope* (C. al′o-pe).—This species closely resembles the preceding, but it is distinguished by the presence of a distinct yellow or pale orange band on the outer half of the fore wings.

The larvæ of both of these species feed upon grass; the butterflies fly during the latter half of the summer, and the larvæ begin hibernating as soon as hatched.

The Hybrid Graylings, *Cercyonis alope-nephele.*—The Dull-eyed Grayling is a northern species, occurring in Canada and the northern part of the United States. The Blue-eyed Grayling is found throughout the greater part of the United States east of the Rocky Mountains, except in the extreme North and South. The ranges of the two overlap in the southern portions of New England, New York, Michigan, Wisconsin, Iowa, and Nebraska; and in the northern portions of Illinois, Indiana, and Ohio. In this belt both species occur, and also intergrades between them; these intergrades may be called Hybrid Graylings.

The White Mountain Butterfly, *Œneis semidea* (Œ-ne'is se-mid'e-a).—Comparatively few students who study this book will collect this butterfly; but we refer to it on account of its remarkable distribution. It is found only on the higher parts (above 5000 feet) of the White Mountains in New Hampshire, and on the highest peaks of the Rocky Mountains of Colorado, above 12,000 feet.

These two widely separated colonies of this butterfly are believed to be the remnants of an Arctic fauna which was forced southward during the Ice Age. At the close of this period, as the Arctic animals followed the retreating ice northward, the tops of these mountains became colonized by the cold-loving forms. Here they found a congenial resting place, while the main body of their congeners, which occupied the intervening region, was driven northward by the increasing heat of the lower land. Here they remain, clinging to these islands of cold projecting above the fatal sea of warmth that fills the valleys below.

CHAPTER XIX.

Order DIPTERA (Dip'te-ra).

The Flies.

The members of this order have only two wings; these are borne by the mesothorax. The metathorax is furnished with a pair of knobbed threads, the halteres. The mouth-parts are formed for sucking. The metamorphosis is complete.

To the order Diptera belong all insects that are properly termed flies, and only these. The word "fly" forms a part of many compound names of insects of other orders, as butterfly, stone-fly, May-fly, and Chalcis-fly; but when used alone, it is correctly applied only to dipterous insects. To some flies other common names have been applied, as mosquito, gnat, and midge.

The name Diptera is from two Greek words: *dis*, two, and *pteron*, a wing. It was suggested by the fact that the flies are distinguished by the possession of a single pair of wings; for no fly has more than two wings, and only a few are wingless.

The wings of flies are thin, membranous, and usually either naked or clothed with microscopic hairs; but with mosquitoes the wings bear scales, and with the moth-like flies (Psychodidæ) and some others the clothing of hairs is very conspicuous. The hind wings are represented by a pair of knobbed threads, the *halteres* (hal-te'res); these can be easily seen in a crane-fly (Fig. 482). The function of

these rudimentary wings is not known; but they doubtless have some important use, for they are present in nearly all flies, even when the front wings are wanting.

The mouth-parts of flies are formed for sucking, and sometimes also for piercing. Their structure differs greatly in different families; and in some cases it is exceedingly difficult to determine the correspondence of the different parts. In the more typical forms the mouth-parts consist of six bristle-like or lance-like organs enclosed in a sheath, and a pair of jointed palpi. A difference of opinion exists as to the correspondence of these parts; but according to the most generally accepted view the six bristles represent the upper lip (*labrum*), the tongue (*hypopharynx*), the two mandibles, and the two maxillæ, and the sheath enclosing these bristles is the lower lip (*labium*). The palpi which are not enclosed in the sheath are the maxillary palpi. At the tip of the lower lip there is, on each side, a lobe-like appendage; these are the labial palpi. The labial palpi of certain flies are quite large; in the House-fly, for example, they are expanded into broad plates, which are fitted for rasping.

FIG. 482.—A crane-fly, showing wings and halteres.

In their transformations flies pass through a complete metamorphosis. The larvæ are commonly called maggots. These are usually cylindrical and are footless; some possess a distinct head, others do not; the form of the mouth-parts varies greatly in the different families; and there are remarkable variations in the form of the respiratory organs, especially as to the number and position of the spiracles. The pupæ are usually either naked or enclosed in the last

larval skin. A few are enclosed in cocoons. When the pupa state is passed within the last larval skin the body of the pupa separates from the larval skin more or less completely; but the larval skin is not broken till the adult fly is ready to emerge. In this case the larval skin, which serves as a cocoon, is termed a *puparium* (pu-pa'ri-um). In some families the puparium retains the form of the larva; in others the body of the larva shortens, assuming a more or less barrel-shaped form (Fig. 483, 2), before the change to a pupa takes place.

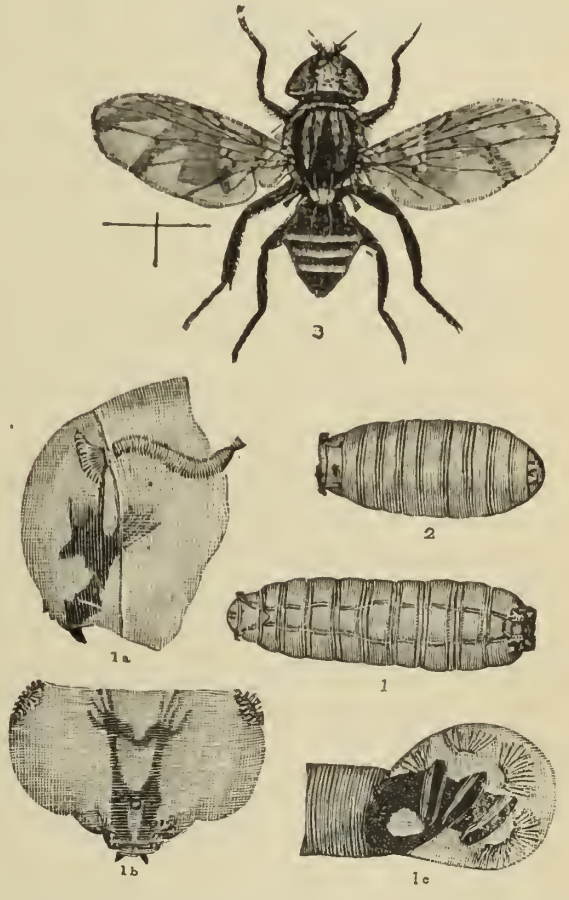


FIG. 483.—The Apple-maggot; 1. larva; 2, puparium; 3, adult; 1a, head of larva from side, showing mouth-parts and cephalic spiracle; 1b, head of larva from below; 1c, caudal spiracle of larva.

This is a large order, both in number of species and individuals. The species differ much in habits. Some are very annoying to man. Familiar examples are the mosquito, which attacks his person; the flesh-flies, which infest his food; the bot-flies and gad-flies that torment his cattle; and the gall-gnats that destroy his crops. Other species are very beneficial. Those belonging to the Syrphidæ, and to the subfamily Tachininæ of the Muscidæ destroy many noxious insects; and very many species, while in the larval state, feed upon decaying animal and vegetable matter, thus acting as scavengers.

Although the habits of these creatures, which revel in all kinds of filth, are very disgusting, we cannot help admiring that arrangement by which a mass of filth, instead of

being left to poison the atmosphere, is transformed into myriads of living beings, whose swift flight and delicate forms lend life and beauty to the landscape.

SYNOPSIS OF THE DIPTERA.

THE STRAIGHT-SEAMED FLIES.—Flies in which the pupa escapes from the larval skin through a T-shaped opening, which is formed by a lengthwise split on the back near the head end and a crosswise split at the front end of this (Fig. 484), or rarely through a crosswise split between the seventh and eighth abdominal segments, adults without a frontal lunule.* Suborder ORTHORRHAPHA (Or-thor'rha-pha).

FIG. 484.

The Long-horned Orthorrhapha or Nematocera (Nem-a-toc'e-ra). Flies with four- or five-jointed pendulous palpi and with many-jointed antennæ, which are usually long. The segments of the antennæ, except the basal two, are similar in form, and are more than six in number; they are often fringed with hairs or bristles.†

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* The *frontal lunule* is a small crescent-shaped piece immediately above the antennæ, which is characteristic of the second suborder, the Cyclorrhapha. In most of the members of this suborder there is a suture separating the lunule from that part of the head above it, the *frontal suture;* and frequently this suture extends down on each side to near the mouth (Fig. 485). But as the suture is wanting in several families of the Cyclorrhapha, it is often difficult to determine whether the lunule is present or not. The following statement will enable the student to recognize nearly all of the members of the first suborder.

FIG. 485. — Head showing frontal suture

The suborder Orthorrhapha includes :—

All flies in which the antennæ are more than three-jointed, not counting a bristle or style borne by the third segment.

All flies with three-jointed antennæ in which vein III is four-branched.

Such of the flies in which vein VII_2 appears like a cross-vein, or curves back towards the base of the wing, as lack the suture above the antennæ. This section includes only a few Empididæ and the families Do ichopodidæ and Lonchopteridæ. Nearly all of the flies in which vein VII_2 is of the form described here possess the suture above the antennæ, and hence belong to the Cyclorrhapha.

† The two types of antennæ characteristic of the Nematocera and Brachycera respectively are connected by intermediate forms. These

The True Nematocera. The antennæ usually long and frequently bearing whorls of long hairs, especially in the males; legs long and slender; abdomen usually long and slender.

The Moth-like Flies, Family PSYCHODIDÆ. p. 428.

The Midge-like Flies.

The Crane-flies, Family TIPULIDÆ. p. 429.

The Net-winged Midges, Family BLEPHAROCERIDÆ, p. 432.

The Dixa-midges, Family DIXIDÆ. p. 436.

The Mosquitoes, Family CULICIDÆ. p. 437.

The Midges, Family CHIRONOMIDÆ. p. 440.

The Fungus-gnats, Family MYCETOPHILIDÆ. p. 442.

The Gall-gnats, Family CECIDOMYIIDÆ. p. 444.

The Anomalous Nematocera. The antennæ are composed of many segments, but are shorter than the thorax, and without whorls of long hairs. The segments of the antennæ are short and broad and closely pressed together. Except in the first family, the abdomen is comparatively stout, and the legs are shorter and stouter than in the True Nematocera.

The False Crane-flies, Family RHYPHIDÆ. p. 448.

The Solitary-midge, Family ORPHNEPHILIDÆ. p. 449.

The March-flies, Family BIBIONIDÆ. p. 449.

The Black-flies, Family SIMULIIDÆ. p. 451.

The Short-horned Orthorrhapha or Brachycera (Bra-chyc'e-ra). Orthorrhapha with one- or two-jointed, porrect palpi, and with usually short, three-jointed antennæ. The third segment of the antenna is sometimes distinctly ringed, showing that it is really composed of many segments grown together; and sometimes the antennæ are four- or five-jointed.

The Anomalous Brachycera. The third segment of the antenna is ringed, showing that it is composed of several segments grown together. The body is not furnished with strong bristles.

The Horse-flies, Family TABANIDÆ. p. 453.

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occur in those families grouped below as the Anomalous Brachycera (see Figs. 489, 490, and 492). The Nematocera and Brachycera are more sharply distinguished by the form of the palpi, as indicated in this Synopsis; but sometimes it is difficult to see the palpi. A more easily seen distinction is presented by the venation of the wings. In the Anomalous Brachycera cell V_2 is divided by a cross-vein and cell VIII is closed before the margin of the wing or is greatly narrowed at the margin of the wing (see Figs. 539, 545, and 551). In the Nematocera cell VIII is never closed, and cell V_2 is divided only in the Tipulidæ and Rhyphidæ, and in these families the antennæ are distinctly composed of many segments.

The Soldier-flies, Family STRATIOMYIIDÆ. p. 455.
The Snipe-flies (in part), Family LEPTIDÆ. p. 456.

The True Brachycera. The antennæ are usually three-jointed, but sometimes four- or five-jointed; the third segment is not ringed, but usually bears a style or bristle.* The body is usually furnished with strong bristles.

True Brachycera with the empodia pulvilliform. Flies in which there are three membranous lobes beneath the tarsal claws (Fig. 495).†

The Snipe-flies (in part), Family LEPTIDÆ. p. 456.
The Small-headed Flies, Family ACROCERIDÆ. p. 458.
The Tangle-veined Flies, Family NEMISTRINIDÆ, p. 459.

True Brachycera with the empodia not pulvilliform. Flies in which there are only two membranous pads beneath the tarsal claws (Fig. 494).

Vein III of the wings four-branched.

The Robber-flies, Family ASILIDÆ. p. 460.
The Midas-flies, Family MIDAIDÆ. p. 461.
The Apiocerids, Family APIOCERIDÆ. p. 462.
The Bee-flies, Family BOMBYLIDÆ. p. 463.
The Stiletto-flies, Family THEREVIDÆ. p. 464.
The Window-flies, Family SCENOPINIDÆ. p. 465.
The Dance-flies (in part), Family EMPIDIDÆ. p. 466.

Vein III of the wings three-branched.

The Dance-flies (in part), Family EMPIDIDÆ. p. 466.
The Long-legged Flies, Family DOLICHOPODIDÆ. p. 467.
The Spear-winged Flies, Family LONCHOPTERIDÆ. p. 469.

THE CIRCULAR-SEAMED FLIES. — Flies in which the pupa escapes from the larval skin through a circular orifice made by pushing off the head end of it (Fig. 486). Adults with a frontal lunule. Suborder CYCLORRHAPHA (Cy-clor'rha-pha).

FIG. 486.

Cyclorrhapha without a frontal suture (ASCHIZA).

The Syrphus-flies, Family SYRPHIDÆ. p. 470.
The Big-eyed Flies, Family PIPUNCULIDÆ. p. 473.
The Flat-footed Flies, Family PLATYPEZIDÆ. p. 474.
The Humpbacked flies, Family PHORIDÆ. p. 475.

* A similar type of antenna is possessed by the Cyclorrhapha, which were formerly on this account included in the Brachycera; but this term is now restricted to the Short-horned Orthorrhapha.

† The empodia are pulvilliform in the Anomalous Brachycera also; but that group is easily distinguished by the form of the antennæ.

Cyclorrhapha with a frontal suture (SCHIZOPHORA)
Normal Schizophora.
The Thickhead-flies, Family CONOPIDÆ. p. 476.
The Bot-flies, Family ŒSTRIDÆ. p. 477.
The Muscids, Family MUSCIDÆ. p. 479.
The Pupa-bearing Flies (PUPIPARA).
The Louse-flies, Family HIPPOBOSCIDÆ. p. 487.
The Bat-ticks, Family NYCTERIBIIDÆ. p. 489.
The Bee-louse, Family BRAULIDÆ. p. 489.

Classification of the Diptera.

(*For advanced students.*)

In the following table for determining the families of the Diptera use is made chiefly of characters based on the form of the head, antennæ, and wings.

The more important of the characters presented by the head are the presence or absence of the frontal lunule, and the presence or absence of the frontal suture when the lunule is present. (See page 416, note.) In those families that possess the frontal suture there exists a large bladder-like organ, the *ptilinum* (ptil'i-num), which is pushed out through this suture when the adult is about to emerge from the puparium. In this way the head end of the puparium is forced off, making a large opening through which the adult escapes; afterwards the ptilinum is withdrawn into the head. If a specimen is captured soon after its emergence from the puparium, there may be seen instead of the frontal suture the bladder-like ptilinum projecting from the head, immediately above the antennæ.

The form of the antennæ is of prime importance in determining to what family a fly belongs. In the more generalized families the antenna consists of many segments, which, except the basal two, are similar in form (Fig. 487). Frequently such antennæ bear whorls of long hairs (Fig. 488). In the more specialized families there is a reduction in the number of segments of the antenna. This is brought about either by a more or less complete consolidation of the segments beyond the second into a single segment (Figs. 489 and 490), or by a dwindling of the terminal segments, so that they form merely a slender style (Fig. 491) or bristle (Fig. 492). Such a bristle is termed by many writers the *arista* (a-ris'ta). In most cases where a style or arista exists it is borne by the third segment, and this segment is then usually greatly enlarged. When the enlargement of this segment has taken place evenly the style or arista is terminal; but frequently one part of the third segment is expanded so that it projects beyond the

insertion of the arista (Fig. 493); then the arista is said to be dorsal.

The legs vary greatly in length and in stoutness. The coxæ are usually long, and in most of the fungus-gnats (Mycetophilidæ) they are very long. When pulvilli are developed they are membranous pads, one beneath each tarsal claw. A third appendage, the *empodium* (em-po'di-um), often exists between the two pulvilli of each tar-

FIG. 487. FIG. 488. FIG. 489. FIG. 490. FIG. 491.

sus. The empodia may be bristle-like, or tapering (Fig. 494), or membranous, resembling the pulvilli in form (Fig. 495); in the last case they are described as *pulvilliform*.

Variations in the form and venation of the wings afford characters that are much used in the classification of flies. In many fami-

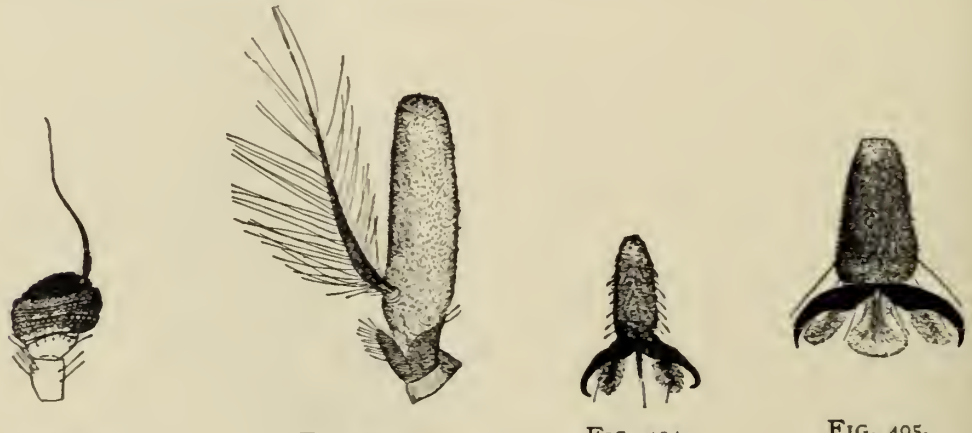

FIG. 492. FIG. 493. FIG. 494. FIG. 495.

lies there is a notch in the inner margin of the wing near its base (Fig. 496, *a e*); this is the *axillary excision;* that part of the wing lying between the axillary excision and the base of the wing is the *posterior lobe* (Fig. 496, *l*). In certain families there is a membrane beneath the base of the wing and above the halter or rudimentary

hind wing; this is the *alula* (al'u-la) or *alulet* (al'u-let). The alulæ are well developed in the common House-fly. Each alula, in those species where the alulæ are well developed, consists of two lobes which fold over each other when the wings are closed. The alulæ are called the *tegulæ* by many writers on Diptera; but the term *tegula*

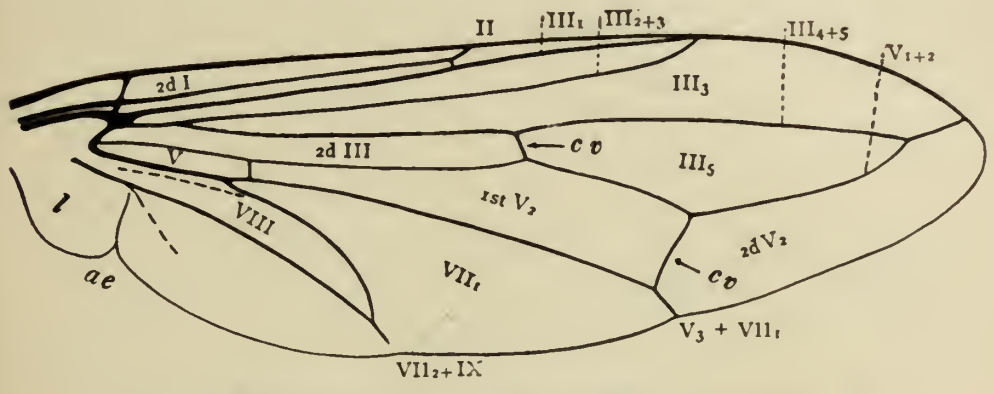

FIG. 496.—Wing of *Conops; ae*, axillary excision; *l*, posterior lobe.

was first used in insect anatomy for the cup-like scale which covers the base of the wing in certain insects, as most Hymenoptera, and should be restricted to that use. The terms alula and alulet are also often misapplied, being used to designate the posterior lobe of the wing.

The plan of the venation of the wings can be easily learned by a study of the wing of *Rhyphus* (Fig. 497), which is very generalized in structure, except that vein III is only three-branched, while in certain still more generalized forms it is five-branched (e.g., *Protoplasa*, Fig. 504; and *Psychoda*, Fig. 500). In the figures of wings in this chapter both the veins and the cells are numbered. The numbers outside of the margin of the wing refer to the veins; those within, to the cells, except when otherwise indicated by a dotted line or by an arrow. It should be remembered that each cell bears the same number as the vein that forms its front margin when the wings are spread. When a cell is divided by a cross-vein the two parts are numbered 1st and 2d. Thus in *Rhyphus*, cell V_2 is divided, and the parts are designated as the 1st cell V_2 and the 2d cell V_2 (Fig. 497, 1st V_2, 2d V_2). A cross-vein is marked *cv*.

In the Diptera veins IV and VI are not developed. Vein I extends along the costal margin of the wing; it usually ends somewhere near the apex of the wing; in *Rhyphus* it ends at the tip of vein III_{4+5} (Fig. 497). In some families it extends entirely around the wing; it is then called the *ambient vein*. Vein II is simple. Vein III is typically five-branched; but the number of branches is usually reduced to

four or to three. Vein V is three-branched in the more generalized forms. Vein VII is two-branched. Vein VIII is usually merely a concave fold just behind vein VII, and parallel with that vein; it is represented in most of the figures of wings by a dotted line. Vein IX is usually present; and sometimes vein XI also exists.

One of the most marked features in the specialization of the wings of Diptera is a tendency of the veins to coalesce from the margin of the wing towards the base. This is illustrated by the wing of *Conops* (Fig. 496). In this genus veins III_{4+5} and V_{1+2} coalesce at the margin of the wing; veins V_3 and VII_1 coalesce for nearly their entire

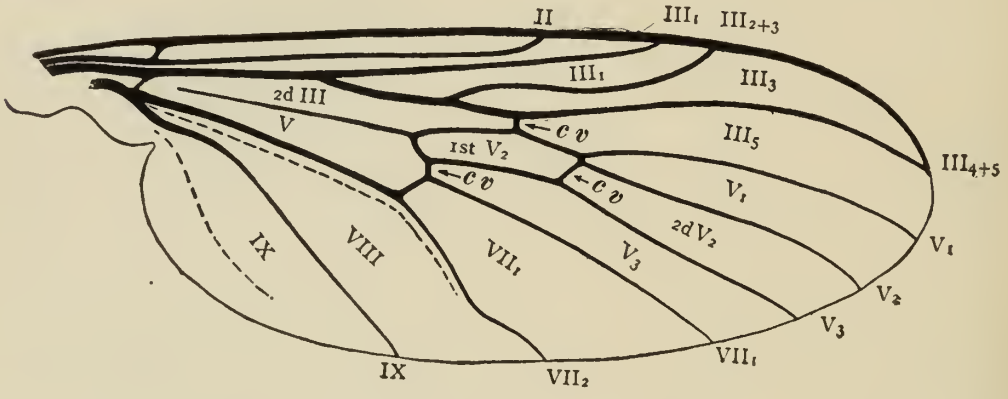

FIG. 497.—Wing of *Rhyphus*.

length. The result of this coalescence is to cause the free part of vein V_3 to appear like a cross-vein between cells V and the 1st cell V_2. Veins VII_2 and IX also coalesce at the margin of the wing.

In a few genera of flies certain longitudinal veins are bent so as to form a sharp angle, and from this angle a spur is developed. Thus in *Protoplasa* there is a sharp angle near the base of vein III_{2+5} which bears a spur (Fig. 504, *s*); in *Erax* a similar spur is formed on vein III_4 (Fig. 559, *s*); and in *Pantarbes* this spur on vein III_4 is prolonged so as to form a complete cross-vein dividing cell III_3 into two parts (Fig. 564).

TABLE FOR DETERMINING THE FAMILIES OF THE DIPTERA.

A. Flies in which the abdomen is distinctly segmented, and the two legs of each thoracic segment are not widely separated. Habits various, but the *adults* do not live parasitically upon either birds or mammals.

B. Antennæ consisting of more than three segments. (Note that a style or bristle borne by the third segment is not counted as a segment.)

C, Antennæ consisting of more than five *distinct* segments, the segments beyond the second not consolidated; cell VIII of the wings but slightly narrowed at the margin of the wing, if at all; palpi usually elongate, and composed of from three to five segments.

D. Small moth-like flies, with the body and wings densely clothed with hairs and scales. Wings with from nine to eleven longitudinal veins, but with no cross-veins except sometimes near the base of the wings (Fig. 500). p. 428. PSYCHODIDÆ.

DD. Flies that do not resemble moths in appearance.

E. Dorsum of thorax with a distinct V-shaped suture (Fig. 503). p. 429.....TIPULIDÆ.

EE. Dorsum of thorax without a distinct V-shaped suture.

F. Vein V of the wings three-branched; cell V_2 divided by a cross-vein (Fig. 527). p. 448.....RHYPHIDÆ.

FF. Vein V of the wings simple or two-branched; cell V_2 not divided by a cross-vein.

G. Wings with a network of fine lines near the outer and inner margins in addition to the veins (Fig. 506). p. 432..... ...BLEPHAROCERIDÆ.

GG. Wings without a network of fine lines.

H. The margin of the wings and each of the wing-veins fringed with scales (Fig. 512). p. 437. CULICIDÆ.

HH. The wing-veins with or without a fringe of hairs, but without a fringe of flat scales.

I. Anal veins entirely wanting; vein V wanting or at most represented by a single unbranched fold (Fig. 522). p. 444.....CECIDOMYIIDÆ.

II. Anal veins present or represented by folds; vein V present or at least represented by a fold which is usually branched.

J. Ocelli present.

K. Antennæ shorter than the thorax; legs comparatively short and stout; coxæ not unusually long. p. 449 .....BIBIONIDÆ.

KK. Antennæ usually longer than the thorax; legs slender, and with greatly elongate coxæ (Fig. 518). p. 442.....MYCETOPHILIDÆ.

JJ. Ocelli absent.

K. Antennæ short, not clothed with long hairs,

and with most of the segments wider than long (Fig. 533); wings very broad (Fig. 534). p. 451.....SIMULIIDÆ.

KK. Antennæ either bushy, being densely clothed with long hairs or slender with narrow segments; wings narrow or moderately broad.

L. Wing-veins well developed on all parts of the wing.

M. Vein III_1 ending at or near the end of the second third of the costal margin. p. 449..... .....ORPHNEPHILIDÆ.

MM. Vein III_1 ending on the outer margin of the wing (Fig. 509). p. 436..DIXIDÆ.

LL. Wing-veins much stouter near the costal margin of the wing than elsewhere (Fig. 517). p. 440.....CHIRONOMIDÆ.

CC. Antennæ either consisting of four or five distinct segments or consisting of five or more segments, with those beyond the second more or less closely consolidated so as to appear as a single segment consisting of several subsegments (Figs. 489, 490, 492, and 537); cell VIII closed by the coalescence of the tips of veins VII_2 and IX, or greatly narrowed at the margin of the wing; palpi rarely elongate, and composed of from one to three segments.

D. Antennæ consisting of four or five distinct segments; empodia wanting or bristle-like.

E. Vein III_5 not curved forward towards the costal margin of the wing (Fig. 559). p. 460.....ASILIDÆ.

EE. Vein III_5 curved forward towards the costal margin of the wing (Fig. 561). p. 461.....MIDAIDÆ.

DD. Antennæ consisting of five or more segments, but with those beyond the second more or less closely consolidated; empodia resembling pulvilli in form (Fig. 495).

E. The branches of vein III crowded together near the costal margin of the wing, and the first cell V_2 unusually short and broad (Fig. 545). p. 455.....STRATIOMYIIDÆ.

EE. Venation of wings normal.

F. The alulets large. p. 453.....TABANIDÆ.

FF. The alulets small or wanting. p. 456.....LEPTIDÆ.

BB. Antennæ consisting of not more than three segments; the

third segment either with or without a style or bristle, but not divided into subsegments.

C. Antennæ consisting apparently of a single globular segment bearing a long bristle; wings with some stout veins near the costal margin and other weaker ones extending across the wing unconnected by cross-veins (Fig. 581). p. 475. PHORIDÆ.

CC. Flies that do not present the type of venation represented by Figure 581.

D. Cells V and first V_2 not separated (see Fig. 571 for an example of this type).

E. Vein III with a knot-shaped swelling at the point of separation of veins III_2+_3 and III_4+_5; the cross-vein III–V at or near this swelling; no suture immediately above the antennæ. p. 467..... DOLICHOPODIDÆ.

EE. Vein III with or without a swelling at the point of separation of veins III_2+_3 and III_4+_5; the cross-vein III–V more remote from base of wing; a suture immediately above the antennæ. p. 479..... MUSCIDÆ.

DD. Cells V and V_2 separate.

E. Vein III four-branched.

F. Venation intricate, due to an unusual anastomosing of the veins (Fig. 555). p. 459..... NEMISTRINIDÆ.

FF. Venation not of the type represented by Figure 555.

G. Vertex of head distinctly hollowed out between the eyes (Fig. 557); eyes never contiguous. p. 460. ASILIDÆ.

GG. Vertex of head not hollowed out between the eyes; eyes often contiguous in males.

H. Alulets very large. p. 458..... ACROCERIDÆ.

HH. Alulets small or rudimentary.

I. Cell V_3 present.

J. Vein III_5 ending before the apex of the wing (Fig. 562). p. 462..... APIOCERIDÆ.

JJ. Vein III_5 not ending before the apex of the wing.

K. Empodia pulvilliform, *i.e.*, with three membranous lobes beneath the tarsal claws (Fig. 495). p. 456..... LEPTIDÆ.

KK. With only two membranous lobes beneath the tarsal claws. p. 464..... THEREVIDÆ.

II. Cell V_3 obliterated by the coalescence of veins V_3 and VII_1.

J. Third segment of antennæ without bristle or style; vein V_1 ending at or before the apex of the wing (Fig. 568). p. 465.....SCENOPINIDÆ.

JJ. Third segment of antennæ usually with bristle or style; vein V_1 ending beyond the apex of the wing.

K. Vein VII_2 extending free to the margin of the wing or coalesced with vein IX for a short distance (Fig. 564). p. 463.....BOMBYLIDÆ.

KK. Vein VII_2 joining vein IX far from the margin of the wing, often extending towards the base of the wing (Fig. 569). p. 466. EMPIDIDÆ.

EE. Vein III with not more than three branches.

F. Wings lanceolate, and with no cross veins except at the base (Fig. 572). p. 469.....LONCHOPTERIDÆ.

FF. Wings not of the type represented by Figure 572.

G. Flies with a very small head; with the thorax and abdomen inflated, giving the body a hunchback-like appearance, and with the alulets very large. The empodia pulvilliform, *i.e.*, with three membranous lobes beneath the tarsal claws. p. 458.....ACROCERIDÆ.

GG. Head of ordinary size or very large; form of thorax and abdomen various; alulets either large or small. The empodia not pulvilliform, *i.e.*, only two membranous lobes beneath the tarsal claws.

H. Vein VII_2 appearing as a cross-vein or curved back towards the base of the wing (Figs. 569, 588).

I. Antennæ with a terminal style or arista. p. 466. EMPIDIDÆ.

II. Antennæ with a dorsal arista.

J. Proboscis rudimentary; mouth-opening small; palpi wanting. p. 477.....ŒSTRIDÆ.

JJ. Proboscis not rudimentary; palpi present.

K. Head with a suture immediately above the antennæ through which the ptilinum is protruded and withdrawn (Fig. 587). p. 479. MUSCIDÆ.

KK. Head without such suture. p. 466. EMPIDIDÆ.

HH. Vein VII_2 not coalesced with vein IX to such an

extent as to cause the free part to appear like a cross-vein.

I. Antenna with a terminal style or bristle.

J. Antenna with a terminal bristle. p. 474. PLATYPEZIDÆ.

JJ. Antenna with a terminal style.

K. Front with grooves or a depression beneath the antennæ. p. 476.....CONOPIDÆ.

KK. Front convex beneath the antennæ. p. 470.....SYRPHIDÆ.

II. Antenna with dorsal bristle.

J. Head extremely large, and with nearly the entire surface occupied by the eyes (Fig. 577). p. 473.....PIPUNCULIDÆ.

JJ. Head not of the type represented by Figure 577.

K. Wings with a vein-like thickening, the spurious vein, between veins III and V (Fig. 574). p. 470.....SYRPHIDÆ.

KK. Wings without a spurious vein.

L. Front with grooves or a depression beneath the antennæ. p 476..... CONOPIDÆ.

LL. Front convex beneath the antennæ. p. 470.....SYRPHIDÆ.

AA. Flies in which the abdomen is indistinctly segmented, and the two legs of each segment are widely separated by the broad sternum. The *adults* live parasitically upon birds, mammals, or the Honey-bee.

B. Compound eyes present; wings present or absent. p. 487. HIPPOBOSCIDÆ.

BB. Both compound eyes and wings absent.

C. Halteres present; tarsal claws of ordinary form. Adults parasite upon bats. p. 489.....NYCTERIBIIDÆ.

CC. Halteres absent; last segment of tarsus with a pair of comb-like appendages. p. 489.....BRAULIDÆ.

Suborder ORTHORRHAPHA (Or-thor′rha-pha).

The Straight-seamed Flies.

To this suborder belong those families of flies in which the pupa escapes from the larval skin through a T-shaped

opening, which is formed by a lengthwise split on the back near the head-end and a crosswise split at the front end of this (Fig. 498). In a few members of this suborder (i.e., some of the Cecidomyiidæ) the pupa escapes through a crosswise split between the seventh and eighth abdominal segments. The pupæ are usually either naked or enclosed in the last larval skin, the puparium; but the pupæ of some of the gall-gnats, Cecidomyiidæ, are enclosed in cocoons. The adult flies do not possess a frontal lunule. See footnote page 416.

FIG. 498.

Family PSYCHODIDÆ (Psy-chod'i-dæ).

The Moth-like Flies.

There may be found frequently upon windows and on the lower surface of the foliage of trees small flies which have the body and wings densely clothed with hair and which resemble tiny moths in appearance. The wings are broad, and when at rest slope at the sides in a roof-like manner or are held horizontally in such a way as to give the insect a triangular outline (Fig. 499).

FIG. 499.—A moth-like fly.

The moth-like appearance of these insects is sufficient to distinguish them from all other flies. The venation of the

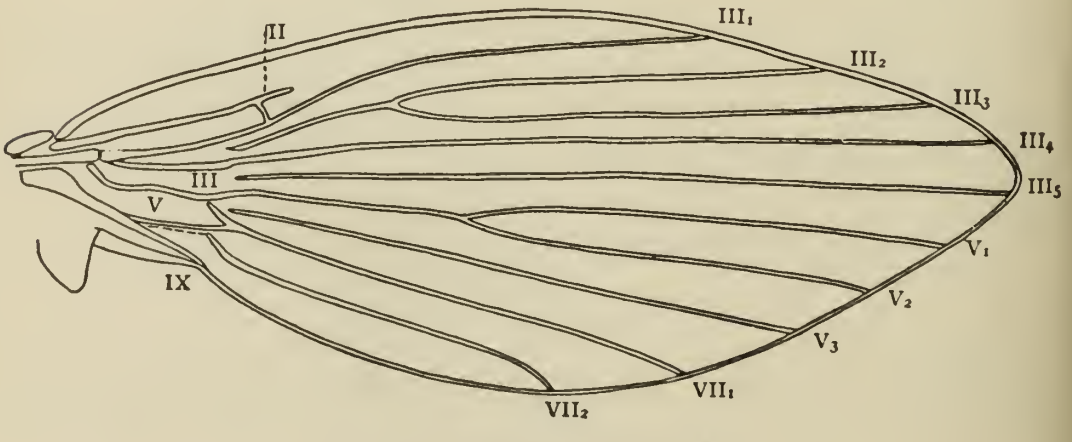

FIG. 500.—Wing of a moth-like fly.

wings (Fig. 500) is also very peculiar. All of the longitudinal veins separate near the base of the wing except veins III_2 and III_3 and veins V_1 and V_2. In some forms veins III_4 and III_5 are distinct, as shown in the figure; in others they coalesce completely, so that radius is only four-branched. In this case there is only a single vein between the two forked veins.

The antennæ are long and slender, and are clothed with whorls of hairs (Fig. 501). Those of the male are longer; and in the species figured the two basal segments are clothed with scales like those of the Lepidoptera. Scales of this form occur also on the wings, palpi, and legs of certain species.

FIG. 501. — Antennæ of *Psychoda*. *m*, antenna of male and the second segment of the same more enlarged; *f*, antenna of female and the tip enlarged.

Only a few of the American species have been described; these have been placed in the genus *Psychoda;* the early stages of none of them have been observed. The larvæ of some European species inhabit cow-dung, and others live in water. They have a pair of spiracles at each end of the body.

As regards the structure of their wings these flies are very distinct from all others. The pre-anal area, that part lying in front of vein VIII, presents an extremely generalized form. This is shown by the outline of the wing (a line drawn lengthwise of the wing through its centre will divide it into two similar parts), the small extent to which the veins coalesce, and the fact that the maximum number of veins is present. On the other hand, the anal area is so reduced as to be barely represented. The dotted line in the figure represents the position of what is left of the anal furrow (i.e., vein VIII).

Family TIPULIDÆ (Ti-pu'li-dæ).

The Crane-flies.

The crane-flies are mosquito-like in form; but they are usually very much larger than mosquitoes. The body is long and slender, the wings narrow, and the legs very

long (Fig. 502). This family includes the larger members of that series of flies in which the antennæ are thread-like; but it also includes some species that are not larger than certain mosquitoes. The most distinctive feature of crane-flies is the presence of a transverse V-shaped suture on the dorsal side of the mesothorax (Fig. 503).

FIG. 502.—A crane-fly.

FIG. 503.—Thorax of a crane-fly showing the V-shaped suture.

The wings are long and narrow. In a few genera vein III is five-branched, and the branches separate near the middle of the wing (Fig. 504); but usually the number of

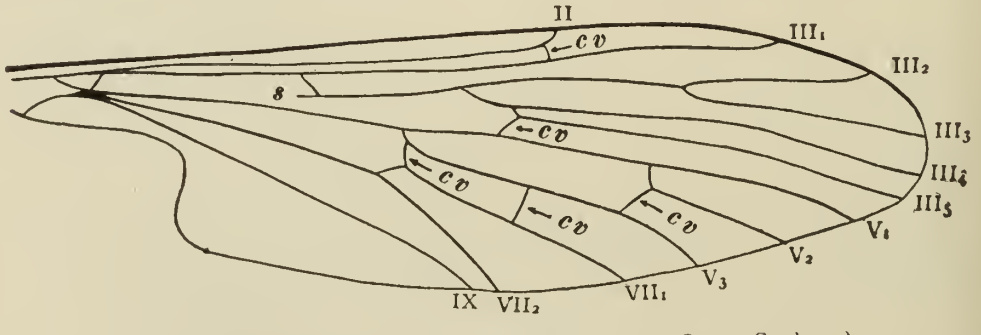

FIG. 504.—Wing of *Protoplasa fitchii*. (After Osten Sacken.)

branches is reduced to three or four; and those that remain distinct separate near the apex of the wing (Fig. 505). Cell V_2 is divided into two parts by a cross-vein; the branches of vein VII like those of vein III separate near the distal end of the wing; and the margin of the wing is strengthened by an ambient vein.

The structure of the ovipositor is also quite distinctive, being composed of two pairs of long, horny, pointed valves. These are fitted for depositing the eggs in the ground, or in other firm substances.

The larvæ of most species live in the ground; and some of them destroy grass and grain by gnawing the young plants just below the surface of the soil. Those of other species live in various situations, as in water, in decaying wood, in fungi, and even on the leaves of plants. The larvæ

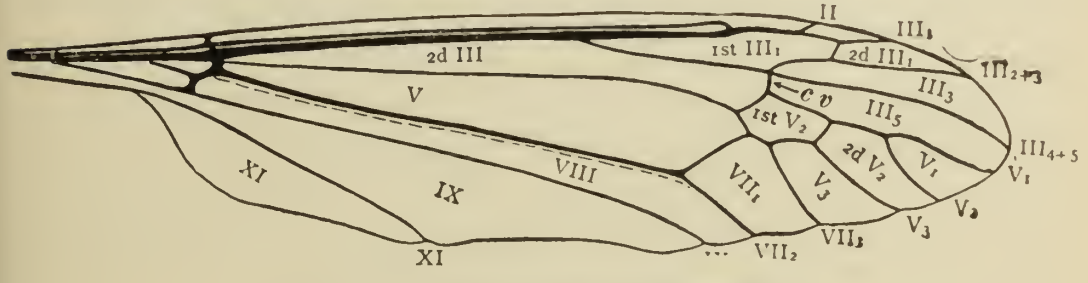

FIG. 505.—Wing of *Tipula abdominalis.*

of this family have either a single pair of spiracles situated at the hind end of the body, or they have two pairs, one at each end of the body. The pupæ are not enclosed in a puparium, and bear transverse rows of hairs, bristles, or spines, which enable them to work their way out from the earth when about to transform.

Crane-flies often appear in great numbers, flying over meadows and pastures. But in most cases their power of flight does not seem to be well developed; for they fly slowly, and only a short distance at a time. Some species, however, sustain themselves in the air for long periods. This is especially true of some of the smaller species; which often collect in swarms at twilight, forming a small cloud, and dancing up and down like some of the midges. But even with these the flight is poor compared with that of the more specialized families, as the Syrphidæ or the Muscidæ. Their ability to walk is also poor; for they use their long legs awkwardly, as if they were in the way. This has suggested the rhyme: —

> "My six long legs, all here and there,
> Oppress my bosom with despair."

Not only are the legs of crane-flies poorly fitted for locomotion, but they are so feebly attached to the body that they are easily broken off; however, the loss of a few legs does not seem to be a serious matter to one of these insects. Yet from what we know of the laws of development we are forced to believe that the peculiar form of the legs has been attained in order to fit them to perform better some important function. It may be that the great length of the legs is correlated with the unusual length of the abdomen and ovipositor, and enables the insect to oviposit in a better manner than would otherwise be possible. When about to lay her eggs, the female stands nearly upright and, bringing the abdomen at right angles to the surface of the earth, thrusts the ovipositor into the ground. After placing one or two eggs in the hole thus made, she moves forward a few steps and repeats the operation.

Family BLEPHAROCERIDÆ (Bleph-a-ro-cer'i-dæ).

The Net-winged Midges.

The net-winged midges are extremely remarkable insects; for in certain respects the structure of the adults is very peculiar, and the larvæ appear much more like Crustaceans than like Insects.

The adults are mosquito-like in form; but they differ from all other insects in having the wings marked by a network of fine lines which extend in various directions and are not influenced at all by the veins of the wing (Fig. 506); they are, however, quite constant in their position in the species that we have studied.

When a wing is examined with a microscope, the fine lines are seen to be slender thickenings extending along the courses of slight folds in the wing. The significance of these folds is evident when a net-winged midge is observed in the act of issuing from its pupa-skin. When the wing is first pulled out of the wing-sheath of the pupa, that part of

it which is crossed by the fine lines is plaited somewhat like a fan and folded over the other portion. By this means the wing, which is fully developed before the adult emerges, is packed within the wing-sheath of the pupa, which is much shorter and narrower than the wing. When the wing is

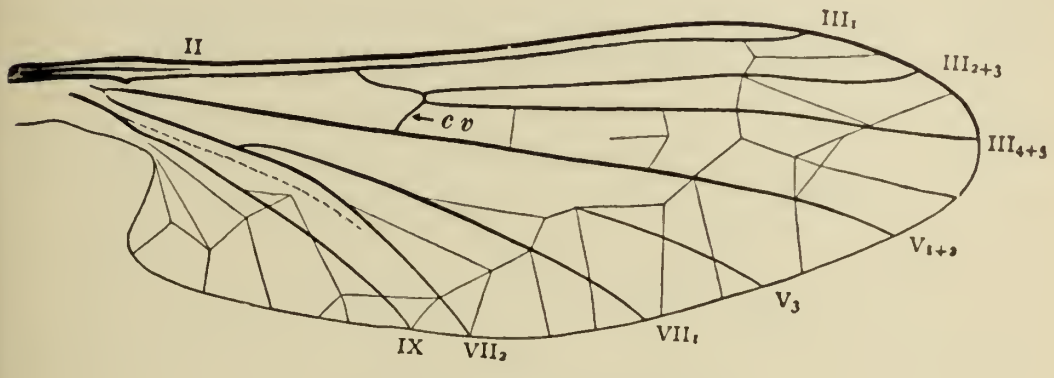

FIG. 506.—Wing of *Blepharocera*.

finally unfolded, it does not become perfectly flat, but slight, alternating elevations and depressions remain, showing the positions of the former folds, a permanent record of the unique history of the wings of these insects.

Ordinarily the wings of insects, while still in the wing-sheaths of the pupa, are neither longer nor wider than the wing-sheaths, but expand after the adult emerges from the pupa skin. Usually it takes considerable time for the wings to expand and become fit for flight; and during this interval the insect is in an almost helpless condition. In certain caddice-flies that emerge from swiftly-flowing water, the time required for the expansion of the wings has been reduced to the minimum (see pp. 189, 190). In the net-winged midges, which also emerge from swiftly-flowing water, the difficulty is met by the wings reaching their full development before the adult leaves the pupa-skin. It is only necessary when the adult emerges from the water that it should unfold its wings to be ready for flight.

The members of this family have three simple eyes. Each compound eye is divided into two parts: an upper half, in which the ocelli are very large; and a lower half, in

which the ocelli are small. The antennæ are thread-like, but are not furnished with whorls of long hairs (Fig. 507).

Fig. 507.

The legs are very long. On the dorsum of the meso-thorax there is on each side, beginning just in front of the base of the wing, a well-marked suture, like that of the crane-flies; but the two do not meet so as to form a continuous V-shaped suture as in the Tipulidæ.

In some species at least there are two kinds of females, which differ somewhat in the shape of the head. These two forms also differ in habits, one being blood-sucking, the other feeding upon nectar. The adults may be found resting on the foliage of shrubs and trees on the margins of mountain-brooks, or dancing in the spray of waterfalls.

The immature forms of these insects are even more wonderful than are the adults. The larvæ live in water, in swiftly-flowing streams, where the water flows swiftest. We have observed the transformations of *Blepharocera capitata* (Bleph-a-roc'e-ra cap-i-ta'ta), which is abundant in some of the ravines near Ithaca, N. Y.

The larvæ of this species are readily seen on account of their black color, and are apt to attract attention on account of their strange form (Fig. 508, *a*). At first sight the body appears to consist of only seven segments, but careful examination reveals the presence of smaller segments alternating with these. Each of the larger segments except the last bears a pair of conical, leg-like appendages. On the ventral side of the body (Fig. 508, *b*) each of the seven larger segments except the last bears a sucker, the cavity of which extends far into the body, and each

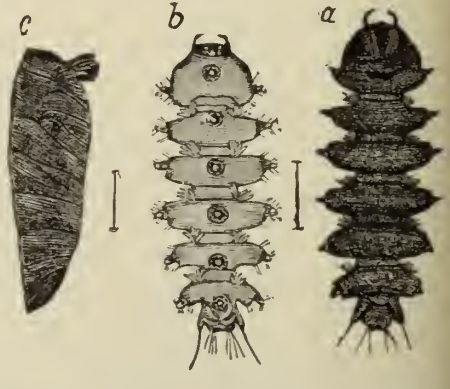

Fig. 508.—*Blepharocera*. *a*, larva, dorsal view; *b*, larva, ventral view; *c*, puparium.

of these segments except the first bears two tufts of tracheal gills; but those of the last segment are united. The head, which forms the front end of the first of the seven larger divisions, bears a pair of slender antennæ; each of these consists of a very short basal segment and two long segments; at the tip of the last of these there is a pair of minute appendages and a bristle. The suture between the head and the remaining part of the first division is best seen on the ventral side of the body. On the dorsal side a suture may be seen dividing the last division into two segments.

The pupa-state is passed in the same place as the larval. Like the larvæ the pupæ are very conspicuous on account of their black color, and are apt to occur like the larvæ closely clustered together. The pupa is not enclosed in the larval skin, and differs greatly in form from the larva. On the dorsal side the skin is hard, forming a convex scale over the body (Fig. 508, *c*); and the thorax bears a pair of breathing-organs; on the ventral side the skin is very delicate, soft, and transparent; so that the developing legs and wings may be easily seen when the insect is removed from the rock. The pupæ cling to the rock by means of six suckers, three on each side near the edge of the lower surface of the abdomen; and so firmly do they cling that it is difficult to remove specimens without breaking them.

We have watched the midges emerge from their pupa-skins and escape from the water. The pupæ occurred in groups so as to form black patches on the rocks. Each one was resting with its head down stream. Each midge on emerging forced its way out through a transverse rent between the thorax and abdomen. It then worked its body out slowly, and in spite of the swift current held it vertical. The water covering the patch of pupæ varied from one fourth to one half inch in depth. In the shallower parts the adult had no trouble in working its way to the surface still clinging to the pupa-skin by its very long hind legs.

While still anchored by its legs the midge rests on the surface of the water for one or two seconds and unfolds its wings; then freeing its legs it takes flight. The adults emerging from the deeper water were swept away by the current before they had a chance to take wing. The time required for a midge to work its way out of the pupa-skin varied from three to five minutes.

Family DIXIDÆ (Dix'i-dæ).

The Dixa-midges.

These midges closely resemble mosquitoes in size and form; but they are easily distinguished by the venation of their wings (Fig. 509).

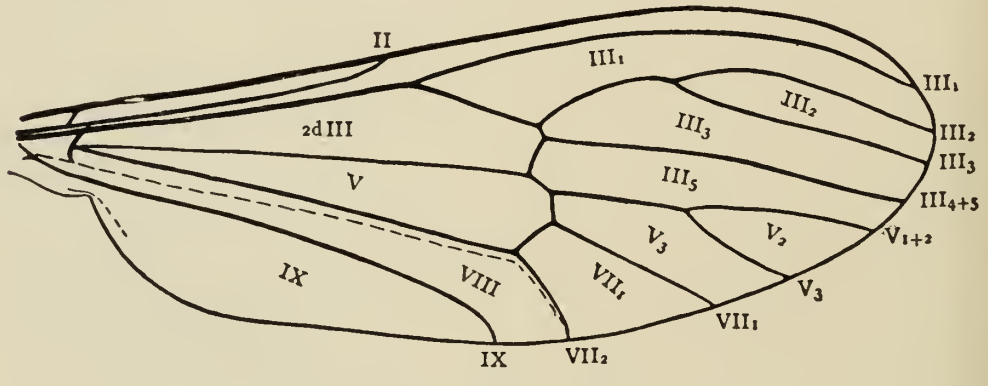

FIG. 509.—Wing of *Dixa*.

The wing-veins are not furnished with scales, and are distinct over the entire surface of the wing; vein I is prolonged into an ambient vein; vein II is well developed, but is short, ending in the margin of the wing near its middle, and before the first fork of vein III; vein III is four-branched; vein V is two-branched; cell V_2 is not divided by a cross-vein; and vein III_1 extends parallel to the margin of the wing to a point on the outer end of the wing. The antennæ (Fig. 510) are sixteen-jointed, and differ but slightly in the two sexes; the legs are very long and slender; and he caudal end of the abdomen of the male is enlarged.

FIG. 510.

The family includes only a single genus, *Dixa*.

We have found the adult midges common on rank herbage, growing in a swampy place, in a shady forest.

Family CULICIDÆ (Cu-lic'i-dæ).

The Mosquitoes.

The form of mosquitoes is so well known that it would be unnecessary to characterize the Culicidæ were it not that there are certain mosquito-like insects that are liable to be mistaken for members of this family.

The mosquitoes are small flies, with the abdomen long and slender, the wings narrow, the antennæ plumose in the males (Fig. 511), and usually with a long, slender, but firm proboscis. The thorax lacks the transverse V-shaped suture characteristic of the crane-flies; and vein V of the wings is only two-branched (Fig. 512). But the most distinctive feature of mosquitoes is a fringe of scale-like hairs on the margin of the wing and also, in all known American forms, on each of the wing-veins.

FIG. 511.—Antennæ of mosquitoes. *m*, male; *f*, female.

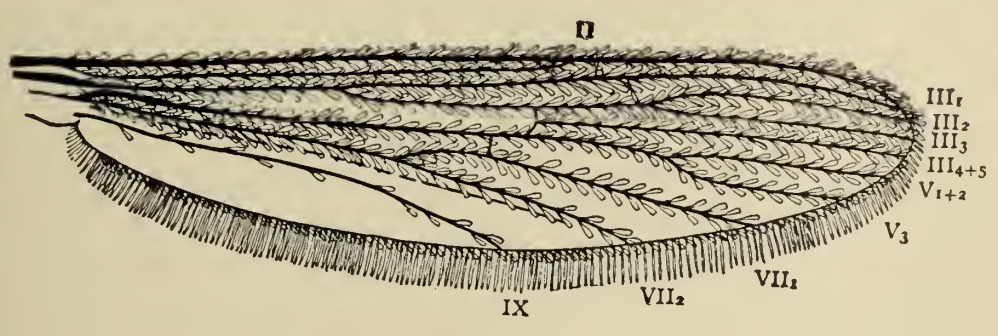

FIG. 512.—Wing of *Culex*.

The larvæ of mosquitoes, so far as they are known, are aquatic. But it is probable that some species breed in the ground, for mosquitoes occur in arid regions far from water.

The transformations of those species with aquatic larvæ are easily observed. The immature forms may be found in

pools of stagnant water, in watering-troughs, and in exposed receptacles of rain-water.

The long, slender eggs are laid side by side in a boat-shaped mass, on the surface of the water (Fig. 513). They

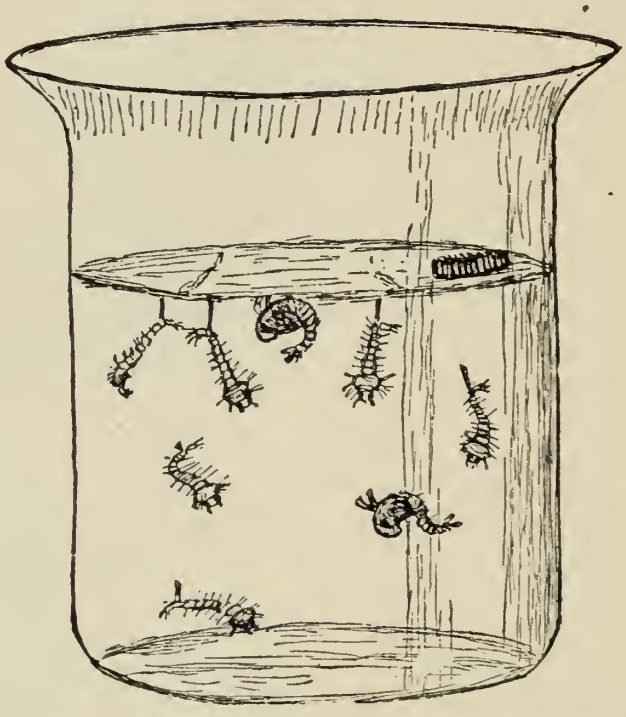

FIG. 513.—A glass of water containing eggs, larvæ, and pupæ of mosquitoes.

hatch in a few days, and the larvæ escape from the lower ends into the water. The larvæ are well known, and are commonly called "wigglers," a name suggested by their wriggling motion as they swim through the water. The larva (Fig. 514, *a*) has a large head and thorax and a slender abdomen. The next to the last abdominal segment bears a breathing-tube; and when the larva is at rest it hangs head downward in the water, with the opening of this tube at the surface (Fig. 513). At the end of this tube there is a rosette of plate-like lobes (Fig. 515, *a*), which, floating on the surface of the water, keeps the larva in position when at rest. The larva grows rapidly, and after a few

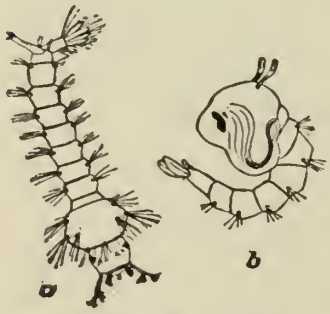

FIG. 514. — Mosquitoes. *a*, larva, *b*, pupa.

molts changes into a club-shaped pupa, the head and thorax being greatly enlarged (514, *b*). With this transformation a remarkable change takes place in the respiratory system. There are now two breathing-tubes, and these are borne by the thorax. One of these tubes is represented greatly enlarged by Figure 515, *b*. At the tail-end of the body there is a pair of leaf-like appendages, with which the insect swims; for the pupæ of mosquitoes, and also of certain midges, differ from the pupæ of other insects in being active. The pupa state lasts only a few days; then the skin splits down the back, and the winged mosquito carefully works itself out and cautiously balances itself on the cast skin, using it as a raft, until its wings are hardened so that it can fly away.

FIG. 515.—*a*, end of breathing-tube of larva; *b*, breathing-tube of pupa.

The larvæ of mosquitoes are doubtless beneficial insects, for they feed on decaying matter in water, and thus act as scavengers; but the annoyance caused by the bites of the adult females more than counterbalances this good. The males of mosquitoes neither sing nor suck blood;* they are said to feed on the sweets of flowers.

These pests can be repelled by smoke and by certain strong-smelling substances. In regions where they abound it is customary to build smudges in the evening for this purpose; and sportsmen anoint their faces and hands with aromatic ointments. The best of these is made of mutton tallow scented with camphor and oil of pennyroyal; a mixture of oil of tar and oil of pennyroyal is also used.

It often happens that plagues of these pests are bred in receptacles of rain-water standing near dwellings; such receptacles should not be left open unnecessarily. When the breeding-places are ponds of limited extent the larvæ and

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* E. Ficalbi states that he has observed two Italian species in which both sexes suck blood. Bull. Soc. Ent. Ital. 1889, p. 25.

pupæ can be destroyed by pouring a small quantity of kerosene on the water; this method of destroying them was first suggested by Mr. L. O. Howard.

Family CHIRONOMIDÆ (Chir-o-nom'i-dæ).

The Midges.

The members of this family are more or less mosquito-like in form. The abdomen is usually long and slender; the wings narrow; the legs long and delicate; and the antennæ, especially in the males, strongly plumose (Fig. 516). In fact many of these insects are commonly mistaken for mosquitoes; but only a few of them can bite, the greater number being harmless.

FIG. 516.—Antennæ of *Chironomus*. *f*, female; *m*, male.

The midges are most easily distinguished from mosquitoes by the structure of the wings (Fig. 517). These are furnished with fewer and usually less

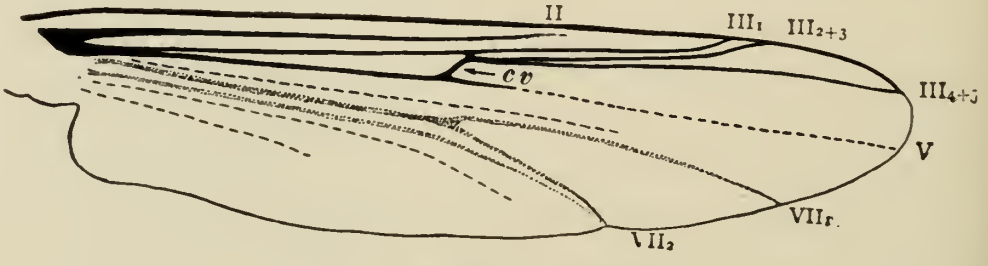

FIG. 517.—Wing of *Chironomus*.

distinct veins; and the veins, although sometimes hairy, are not fringed with scale-like hairs. There is a marked contrast between the stouter veins near the costal border of the wing and those on the other parts of the wing, which seem to be fading out. The costal vein is not prolonged into an ambient vein, beyond the apex of the wing.

The name midge has been used in an indefinite way, some writers applying it to any minute fly. It is much better, however, to restrict it to members of this family

except where it has become firmly established as a part of a specific name. The Wheat-midge and the Clover-seed Midge are examples of names of this kind ; it would not be wise to attempt to change these names, although the insects they represent belong to the Gall-gnat family, and hence are not true midges.

Midges often appear in large swarms, dancing in the air, especially towards the close of day. Professor Williston states that, over meadows in the Rocky Mountains, he has seen them rise at nightfall in most incredible numbers, producing a buzzing or humming noise like that of a distant waterfall, and audible for a considerable distance.

The larvæ are either aquatic or terrestrial; they have two pairs of spiracles, one at each end of the body, or are furnished with tracheal gills. Some of the pupæ are free and active, others are quiescent ; some of the latter remain partially enclosed in the split larval skin.

Many of our species belong to the genus *Chironomus* (Chi-ron′o-mus). These are mosquito-like in form, but vary greatly in size, some being smaller than our common mosquitoes, and others much larger. The head is small, the snout, comparatively short, and the antennæ of the males very bushy. The larvæ so far as they are known are aquatic. Many of them are blood-red in color; and as they live in standing water they are sometimes found in vessels containing rain-water, where they appear like bits of animated red thread. The pupæ of this genus, like those of mosquitoes, are active.

To the genus *Ceratopogon* (Cer-a-to-po′gon) belong the small midges commonly known as punkies. Of these there are many species, which vary greatly in size and color. The body and legs are not as slender as in the preceding genus, and consequently the insects appear much less mosquito-like. Certain minute species are sometimes very abundant, and extremely annoying on account of their bites. We have found them exceeding troublesome in the Adiron-

dack Mountains. The larvæ live under the bark of decaying branches, under fallen leaves, and in sap flowing from wounded trees.

Family MYCETOPHILIDÆ (My-cet-o-phil'i-dæ).

The Fungus-gnats.

These flies are of medium or small size, and more or less mosquito-like in form. They are most easily recognized by the great length of the coxæ (Fig. 518, *c*), and the fact that all the tibiæ are furnished with spurs. They also differ from the closely-allied families in lacking, as a rule, whorls of hairs on the antennæ of the males (Fig. 519), and in possessing ocelli.

FIG. 518. FIG. 519.

At first sight considerable variation seems to exist in the venation of the wings as shown in the three wings represented in Figure 520; but in reality the variations are comparatively slight. Vein I extends along the margin of the wing to the end of vein III_{4+5}. Vein II varies in length. Vein III preserves three branches in the more generalized form (Fig. 520, *a*); in some genera veins III_1 and III_{2+3} coalesce from the apex of the wing backward for a greater or less distance so that the base of vein III_{2+3} appears like a cross vein (Fig. 520, *b*); this coalescence may be complete, in which case vein III is only two-branched (Fig. 520, *c*). Vein V is also two-branched. It should be observed that the cross-vein III–V extends more or less obliquely or even lengthwise of the wing; while the base of vein III_{4+5} may extend transversely, and then is liable to be mistaken for a cross-vein (Fig. 520, *b*, *c*).

The flies are often found in great numbers on fungi and in damp places where there is decaying vegetable matter. They are active, and leap as well as fly.

The larvæ are gregarious, and live in fungi and in decaying vegetable matter. They may be found in the fungi growing on logs and trees, in the vegetable mould among dead leaves, under bark, and sometimes in cow-dung. They have eight pairs of spiracles. One species, *Sciara mali* (Sci'a-ra ma'li), feeds on ripe apples, especially those that have been previously perforated by the Codlin-moth.

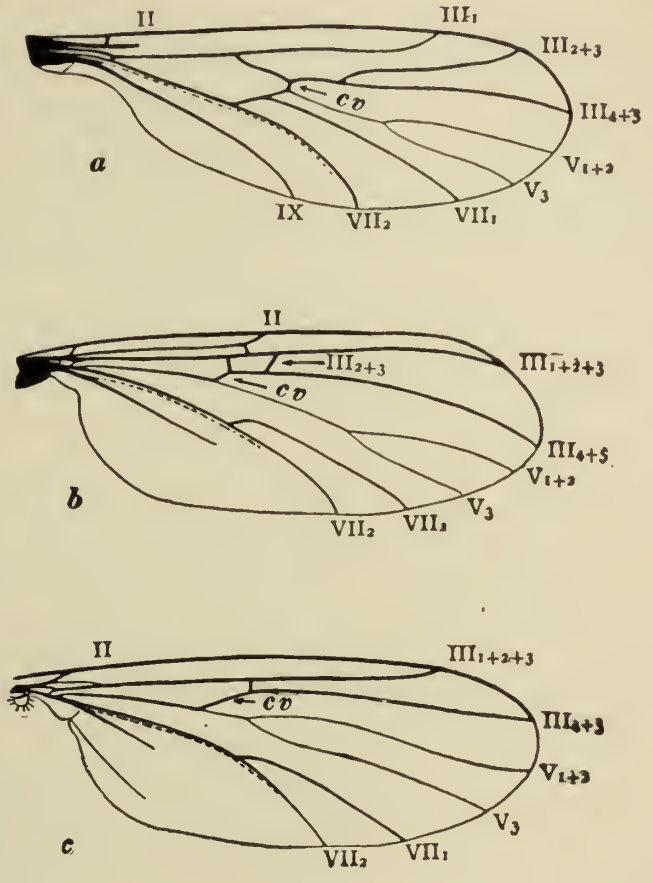

FIG. 520.—Wings of fungus-gnats. (The drawings are after Winnertz; the lettering is original.)

In this family the larva has a distinct head. The pupa is not enclosed in the skin of the larva; but in some genera the transformations are undergone in a delicate cocoon.

The larvæ of some species of the genus *Sciara* often attract attention on account of a strange habit they have of sticking together in dense patches. Such assemblages of larvæ are frequently found under the bark of trees. But what is more remarkable is the fact that when the larvæ are about to change to pupæ an assemblage of this kind will march over the surface of the ground, presenting the appearance of a serpent-like animal. Such a congregation is commonly spoken of as a Sciara-army-worm. Examples have been described that were four or five inches wide and ten or twelve feet long, and in which the larvæ were piled up from

four to six deep. The larvæ crawl over each other so that the column advances about an inch a minute.

Family CECIDOMYIIDÆ (Cec-i-do-my-i′i-dæ).

The Gall-gnats.

The gall-gnats are minute flies which are extremely delicate in structure. The body and wings are clothed with long hairs, which are easily rubbed off. The antennæ are long, sometimes very long, and usually with a whorl of hairs on each segment (Fig. 521); the legs are slender and quite long, but the coxæ are not greatly elongate, and the tibiæ are without spurs; the wing-veins (Fig. 522) are greatly reduced in number; the anal veins being entirely wanting, and vein V wanting or merely represented by a slight, unbranched fold.

FIG. 521. — Antennæ of gall-gnats. *m*, male; *f*. female, enlarged more than that of the male.

To this family belong the smallest of the midge-like flies. On account of their minute size, the adult flies are not apt to attract the attention of the young student. But the larvæ of many

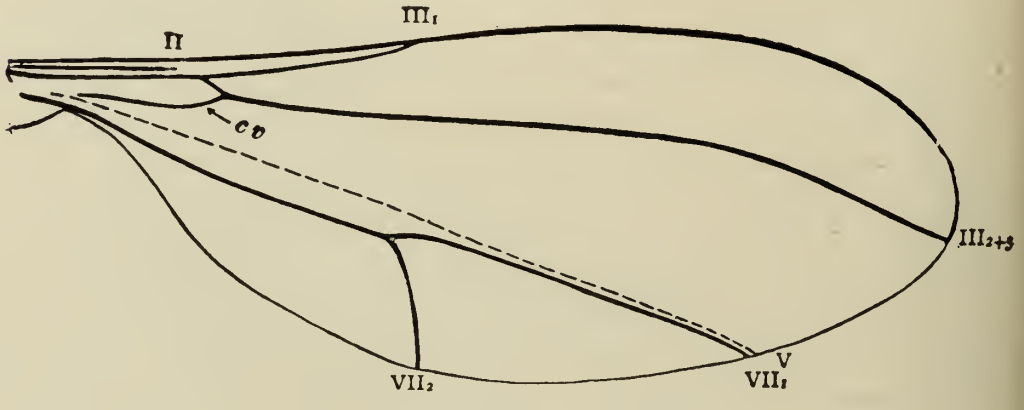

FIG. 522.—Wing of gall-gnat.

species cause the growth of galls on plants; some of which are sure to be found by any close observer. Other species arrest the growth of the plants they infest, and thus cause

very serious injury; in this way the amount of a crop of grain is often greatly reduced.

The larvæ are small maggots, with nine pairs of spiracles. Many species are brightly colored, being red, pink, yellow, or orange. In almost every case a larva belonging to this family can be recognized as such by the presence of a horny piece on the lower side of the body, between the second and third segments (Fig. 523). This piece is called the breast-bone. Its homology and use have not been definitely determined.

FIG. 523. — Head-end of larva showing the breast-bone.

The different species vary as to the method of undergoing their transformation; in some the pupa is naked; in others the pupa is enclosed in the dried skin of the larva; and in still others it is enclosed in a delicate cocoon.

One of the most common and conspicuous of the galls made by gall-gnats is the Pine-cone Willow-gall (Fig. 524). This often occurs in great abundance on the tips of twigs of the Heart-leaved Willow (*Salix cordata*). The gnat that causes the growth of this gall is *Cecidomyia strobiloides* (Cec-i-do-my'i-a strob-i-loi'des). The gall is a deformed and enlarged bud; the lengthening of the stem is checked by the injury caused by the larva; but leaves continue to be developed which results in the cone-shaped growth. The larva remains in the heart of the gall throughout the summer and winter, changing to a pupa early in the spring. The adult

FIG. 524.—The Pine-cone Willow-gall.

emerges soon afterward, and lays its eggs in the newly-started buds of the willow.

There is a guest gall-gnat, *Cecidomyia albovittata* (C. al-bo-vit-ta'ta), which breeds in large numbers between the leaves composing the Pine-cone Willow-gall. The larvæ of this gnat do not seem to interfere in any way with the development of their host, there being abundant food in the gall both for the owner of the gall and for its numerous guests.

The Clover-leaf Midge, *Cecidomyia trifolii* (C. tri-fo'li-i).—The leaflets of white clover are sometimes infested by white or orange-colored maggots which fold the two halves of the leaflet together. From one to twenty of these larvæ may be found in a single leaflet. When full-grown the larvæ make cocoons, and undergo their transformations within the folded leaflet. In Figure 525 an infested leaf containing cocoons is represented natural size, also a larva and an adult gnat, greatly enlarged.

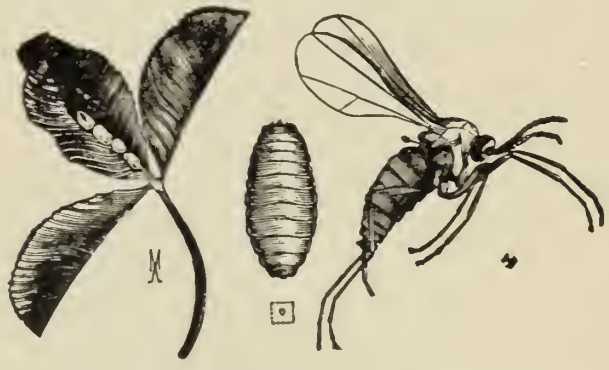

FIG. 525.—*Cecidomyia trifolii*. (From the Author's Report for 1879.)

The Clover-seed Midge, *Cecidomyia leguminicola* (C. le-gu-mi-nic'o-la), is a much more serious pest of clover. This infests both red and white clover. The larvæ live in the heads of the clover and destroy the immature seed. When full-grown they drop to the ground, where they undergo their transformations. In some parts of this country it is impossible to raise clover-seed on account of this pest.

The Hessian-fly, *Cecidomyia destructor* (C. de-struc'tor).—This is perhaps the most serious pest infesting wheat in this country. The larva lives at the base of a leaf between it and the main stalk. There are two or three broods of this insect in the course of the year. The larvæ of the fall brood

infest the young wheat-plants near the surface of the ground. When full-grown each changes to a pupa within a brown puparium, which resembles a flax-seed. Here they remain throughout the winter. In the spring the adult gnats emerge and lay their eggs in the sheaths of leaves some distance above the ground. The infested plants are so weakened by the larva that they produce but little if any seed.

The Wheat-midge, *Diplosis tritici* (Di-plo′sis trit′i-ci).—This gnat is also a very serious enemy of wheat. It deposits its eggs in the opening flowers of wheat. The larvæ feed on the pollen and the milky juice of the immature seeds, causing them to shrivel up and become comparatively worthless. When full-grown the larvæ drop to the ground, where the transformations are undergone near the surface. The adults appear in May or June.

The Resin-gnat, *Diplosis resinicola* (D. res-i-nic′o-la).—This species infests the branches of various species of pine.

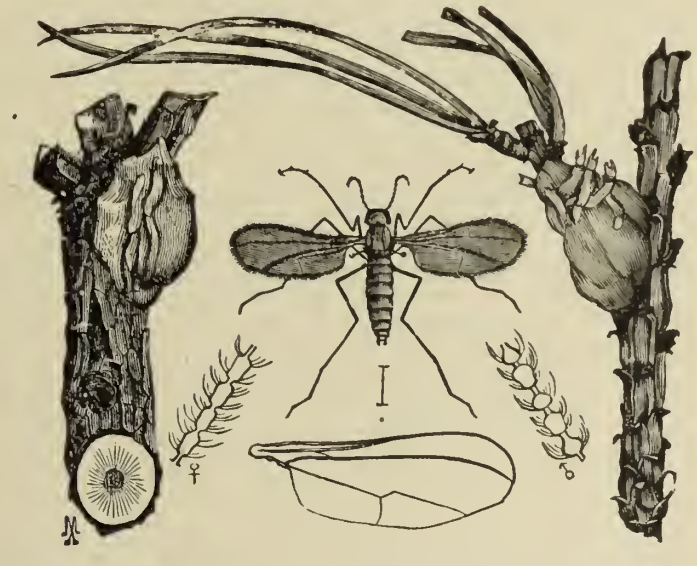

FIG. 526.—*Diplosis resinicola*. (From the Author's Report for 1879.)

We have found it throughout the Atlantic region from New York to Florida. The larvæ live together in considerable numbers within a lump of resin. They derive their nourishment from the abraded bark of the twig; and the resin exuding from the wound completely surrounds and protects

them. The transformations are undergone within the lump of resin. After the gnats emerge the empty pupa-skins project from the lump of resin as shown at the right in Figure 526. In this figure the gnat, a single wing, and a part of the antenna of each sex are represented, all greatly enlarged.

Family RHYPHIDÆ (Rhyph'i-dæ).

The False Crane-flies.

The false crane-flies are so called because they resemble the Tipulidæ somewhat in the venation of the wings, the

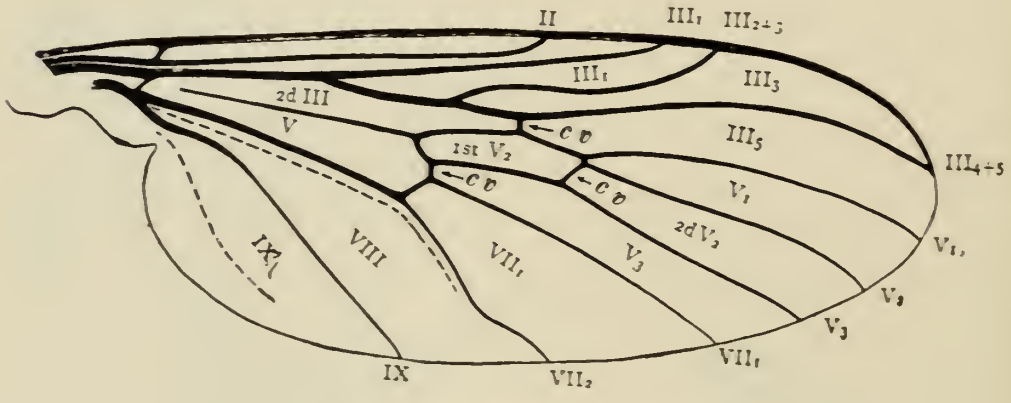

FIG. 527.—Wing of *Rhyphus*.

three branches of vein V being preserved, and cell V_2 being divided by a cross-vein (Fig. 527). They lack, however, the V-shaped suture on the thorax that is characteristic of crane-flies; and differ, also, in having ocelli, and in the structure of the antennæ (Fig. 528). The wings are wider than is usual with crane-flies, and the branches of vein III separate nearer the base of the wing than in that family.

FIG. 528.

The adults are mosquito-like insects with spotted wings, which often enter houses, where they are found on windows. We have also observed them in considerable numbers just at nightfall, feeding on sugar which had been placed on

trees to attract moths. They feed on over-ripe fruit and other vegetable substances.

The larvæ are found in pools and in decaying vegetable matter; they have two pairs of spiracles, one at each end of the body. The pupæ are free.

Only four species of false crane-flies have been found in the United States; these belong to the genus *Rhyphus* (Rhy'phus).

Family ORPHNEPHILIDÆ (Orph-ne-phil'i-dæ).

The Solitary-midge.

Only a single species of this family, *Orphnephila testacea* (Orph-neph'i-la tes-ta'ce-a), is known to occur in North America. This is a small fly measuring about one eighth of an inch in length, with a wing-expanse of one third inch.

The antennæ are short, about as long as the head, and nearly of the same structure in both sexes; the segments of the antennæ except those at the base are slender and are clothed with a few short hairs. The ocelli are wanting. The compound eyes are large and meet in front in both sexes. The wing-veins are well developed on all parts of the wing; vein II ends in the margin of the wing before the end of the basal third; vein III is two-branched, the first branch ending in the margin at the end of the second third of the wing and the other branch near the apex of the wing; vein V is two-branched, the branches separating at the end of the basal third of the wing and near the cross-vein III–V; the fork of vein VII and the cross-vein V–VII are near the end of the basal fourth of the wing.

The transformations of this insect are unknown.

Family BIBIONIDÆ (Bib-i-on'i-dæ).

The March-flies.

In these flies the body is comparatively robust, and the legs shorter and stouter than in most of the families with

thread-like antennæ (Fig. 529). The abdomen, however, is much longer than wide. The antennæ (Fig. 530) are shorter than the thorax, and composed of short, broad, and closely-pressed-together segments. Although the antennæ are hairy, they are not furnished with whorls of long hairs in the males, as is the case in most of the preceding families. These insects resemble the fungus-gnats in having ocelli; but they differ from them in the shortness of the antennæ and in the fact that the coxæ are not greatly elongate. In this family and the following one the eyes of the males are in many cases contiguous. The venation of the wings of the typical genus is represented by Figure 531.

FIG. 529.—*Bibio.*

FIG. 530.

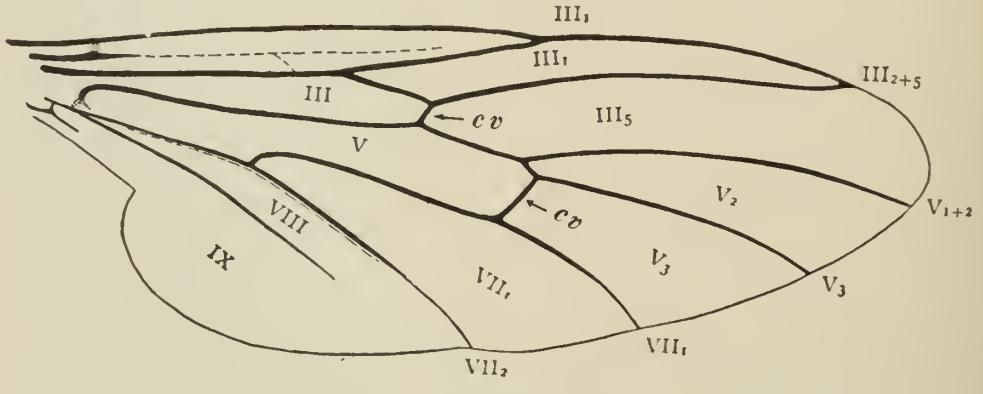

FIG. 531.—Wing of *Bibio.*

The adult flies are generally black and red, sometimes yellow. They are most common in early spring; which has suggested the name March-flies; but some occur later in the season.

The larvæ vary in habits; some species feed on decaying vegetable matter, while others attack the roots of growing plants, especially of grass. They have ten pairs of spiracles; which is an unusually large number, as but few insects have more than nine pairs. The pupæ are usually free.

Family SIMULIIDÆ (Sim-u-li'i-dæ).

The Black-flies.

The common name, black-flies, given to the members of this family is not distinctive, for there are many species in other families that are of this color; but like many other names that are descriptive in form, it has come to have a specific meaning distinct from its original one. It is like the word blackberry; some blackberries are white, and not all berries that are black are blackberries.

In this family the body is short and stout (Fig. 532); the legs are short, and the tibiæ are without spurs. The antennæ, although composed of many segments, are comparatively short, and taper towards the tip (Fig. 533); the segments of the antennæ are short and closely pressed together; they are clothed with fine hairs, but do not bear whorls of long hairs. There are no ocelli. In the males the compound eyes are contiguous, and are composed of two kinds of ocelli, those of one part of the eye being much larger than

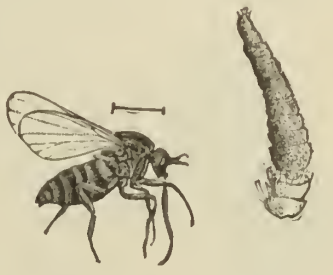

FIG. 532. *Simulium.* FIG. 533.

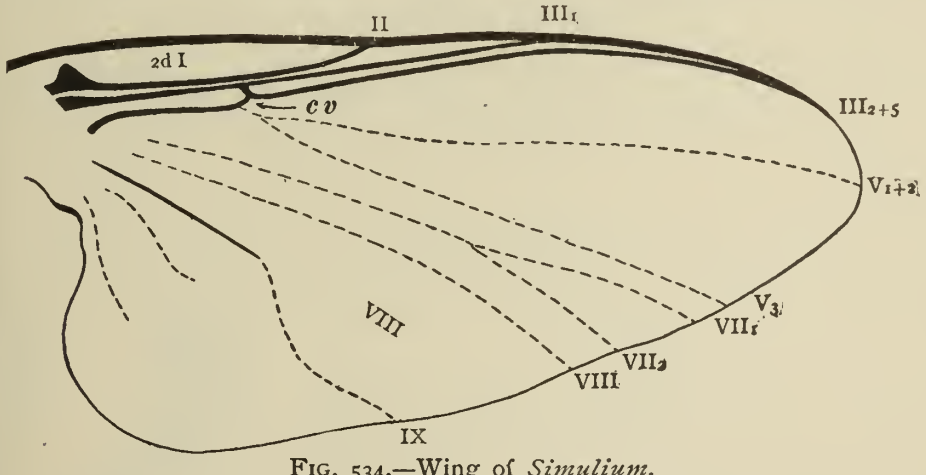

FIG. 534.—Wing of *Simulium.*

the others. The wings are broad, iridescent, and not clothed with hairs. The veins near the costal border are stout; those on the other parts of the wing are very weak (Fig. 534).

The females of many species suck blood and are well-known pests. Unlike mosquitoes and midges, the black-flies like heat and strong light. They are often seen in large numbers disporting themselves in the brightest sunshine.

The larvæ are aquatic; and usually live in swiftly-flowing streams, clinging to the surface of rocks in rapids or on the brinks of falls. They sometimes occur in such large numbers as to form a moss-like coating over the rocks. There is a disk-like sucker fringed with little hooks at the caudal end of the body by means of which the larva clings to the rocks; and just back of the head there is a fleshy proleg which ends in a similar sucker fringed with hooks (Fig. 535).

FIG. 535 — Head of larva.

By means of these two organs the larva is able to walk with a looping gait similar to that of a measuring-worm. It also has the power of spinning silk from its mouth, which it uses in locomotion. The hooks on the caudal sucker and at the end of the proleg are well adapted to clinging to a thread or to a film of silk spun upon the rock to which the larva is clinging. Respiration is accomplished by means of three much-branched tracheal gills which are pushed out from between the last two abdominal segments. The head bears two large fan-shaped organs, which aid in procuring food. The food consists of microscopic plants and bits of tissue of larger plants.

When full-grown the larva spins a boot-shaped cocoon within which the pupa state is passed (Fig. 536). This cocoon is firmly fastened to the rock upon which the larva has lived or to other cocoons, for they occur in dense masses, forming a carpet-like covering on the rocks. The pupa, like the larva, breathes by tracheal gills; but in this stage the tracheal gills are borne by the prothorax.

FIG. 536.—Larva and cocoon.

The adult fly, on emerging from the pupa-skin, rises to the surface of the water and takes flight at once. Soon after this, the eggs are laid. We have often watched the flies hovering over the brink of a fall where there was a thin sheet of swiftly-flowing water, and have seen them dart into the water and out again. At such times we have always found the surface of the rock more or less thickly coated with eggs, and have no doubt that an egg is fastened to the rock each time a fly darts into the water.

The above account is based on observations made on the Innoxious Black-fly, *Simulium innoxium* (Si-mu'li-um in-nox'i-um), which is exceedingly common in the streams about Ithaca, N. Y. This species, fortunately, is not blood-thirsty, for, notwithstanding its great abundance in this locality, we have never known it to bite.

The Southern Buffalo-gnat, *Simulium pecuarum* (S. pec-u-a'rum), of the Mississippi Valley is a terrible pest, which causes the death of many mules and other domestic animals. The popular name of this insect refers to a fancied resemblance in the shape of the insect when viewed from one side to that of a buffalo.

The Turkey-gnat, *Simulium meridionale* (S. me-rid-i-o-na'le), closely resembles the preceding in habits, infesting all kinds of domestic animals; but as it appears at the time that turkeys are setting and causes great injury to this fowl, it is commonly known as the Turkey-gnat.

The Adirondack Black-fly, *Simulium molestum* (S. moles'tum), is a scourge in the mountains of the Northeastern States.

Family TABANIDÆ (Ta-ban'i-dæ).

The Horse-flies.

The horse-flies are well-known pests of stock, and are often extremely annoying to man. They appear in summer, are common in woods, and are most abundant in the hottest weather.

In this family the third segment of the antenna is ringed (Figs. 537, 538) and is never furnished with a distinct style or bristle. The wing-veins (Fig. 539) are evenly distributed over the wing, as the branches of vein III are not crowded together as in the following family; the costal vein extends completely around the wing; the alulets are large.

FIG. 537. Antenna of *Tabanus.*

FIG. 538. Antenna of *Chrysops.*

The flight of these flies is very powerful; they are able to outstrip the swiftest horse. The males feed on the nectar of flowers and on sweet sap. The mouth-parts of the female are fitted for piercing the skin and sucking the blood of men and quadrupeds; the

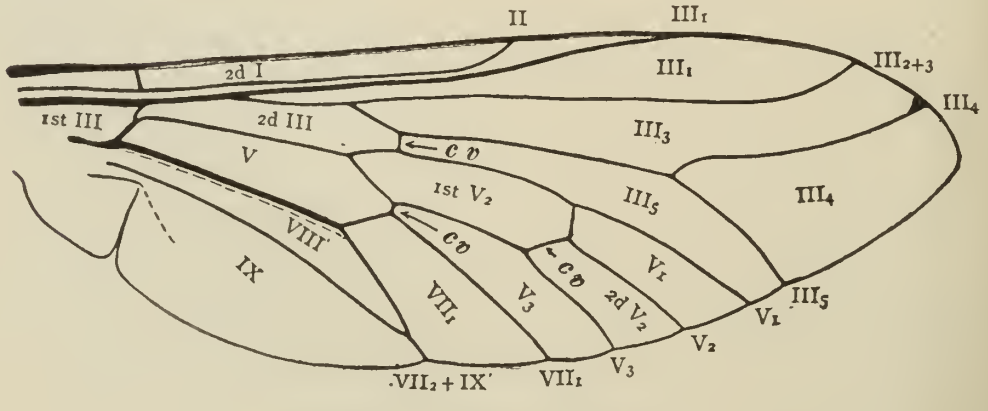

FIG. 539.—Wing of *Tabanus.*

females, however, also feed on the sweets of plants when they cannot obtain blood.

The larvæ are carnivorous; many live in the earth; others live in water. They feed on various small animals; some upon snails, others upon the larvæ of insects. In most cases they have a single pair of spiracles, which is situated at the hind end of the body; some have a pair of spiracles at each end of the body. The pupa is not enclosed in the skin of the larva.

The larger species, as well as some of moderate size, belong to the genus *Tabanus* (Ta-ba'nus), of which nearly one hundred American species are known. One of the most common of these is the Mourning Horse-fly, *Tabanus atratus* (T. a-tra'tus). This insect is of an uniform black color throughout, except that the body may have a bluish tinge (Fig. 540).

FIG. 540.—*Tabanus atratus.*

FIG. 541.—*Chrysops niger.*

To the genus *Chrysops* (Chry'sops) belong the smaller and more common horse-flies with banded wings (Fig. 541). Nearly fifty North American species of this genus have been described.

Family STRATIOMYIIDÆ (Strat-i-o-my-i'i-dæ).

The Soldier-flies.

The soldier-flies are so called on account of the bright-colored stripes with which some of the species are marked. In the more typical members of this family the abdomen is broad and greatly flattened (Fig. 542), and the wings when at rest lie parallel upon each other over the abdomen. But in some genera the abdomen is narrow and considerably elongate.

FIG. 542. *Stratiomyia.*

FIG 543.

FIG. 544.

The antennæ vary greatly in form; in some genera the third segment is long and consists of several quite distinct rings (Fig. 543); in others it is short with but few indistinctly-separated rings and with a bristle (Fig. 544), as in the true true short-horned flies.

The most distinctive characteristic is the peculiar vena

tion of the wings (Fig. 545). The branches of vein III are crowded together near the costal border of the wing; and

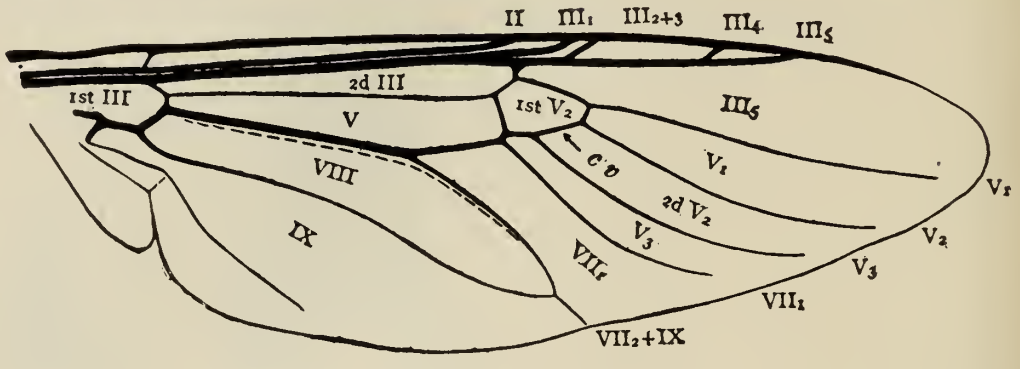

FIG. 545.—Wing of *Stratiomyia*.

the first cell V_2 is unusually short and broad; the branches of Vein V and vein VII, are comparatively weak.

These flies are found on flowers and leaves, especially in the vicinity of water and in bogs and marshes. The larvæ live in water, earth or decaying wood. Some are carnivorous, others feed on decaying vegetable matter. They have six or seven pairs of spiracles; the pupa state is passed within the skin of the larva (Fig. 546).

FIG. 546.—Puparium of *Odontomyia*.

Family LEPTIDÆ (Lep'ti-dæ).

The Snipe-flies.

These trim-appearing flies have rather long legs, a cone-shaped abdomen tapering towards the hind end (Fig. 547), and sometimes a downward-projecting proboscis, which with the form of the body and legs has suggested the name snipe-flies. Some members of the family, however, are remarkable for their resemblance to certain Ichneumon-flies, the abdomen being long and somewhat compressed.

FIG. 547. *Chrysopila thoracica*.

The body is naked or hairy, but it is not clothed with strong bristles. Frequently the hairy covering, though short, is very dense and is of strongly-contrasting colors. Three ocelli are present. The antennæ vary greatly in form; in some

genera the third segment consists of several subsegments, which may be quite distinct (Fig. 548); in others the antennæ are only three-jointed, and the third segment bears a style or bristle (Fig. 549). The proboscis is usually short, only a few members of the family having it long like the bill of a snipe. The wings are broad, and when at rest are held half open. The empodia are pulvilliform; that is,

FIG. 548.—Antenna of *Xylophagus* and, *p*, palpus.

FIG. 549.—Antenna of *Chrysopila*.

FIG. 550.

there are three, nearly equal, membranous pads beneath the tarsal claws (Fig. 550).

Although the form of the antennæ in certain genera closely resembles that characteristic of the long-horned flies (Nematocera), the form of the palpus even in these cases (Fig. 548, *p*) is that characteristic of the short-horned flies (Brachycera), being only two-jointed and not pendulous.

The venation of the wings is comparatively generalized (Figs. 551, 552), each of the principal veins usually extending distinct from the others; but in some veins VII_2 and IX coalesce at the margin of the wing (Fig. 552). Vein III is four-branched; the branches of vein V are connected with adjacent veins only by cross-veins; and cell V_2 is divided by a cross-vein.

The flies are predaceous. They may be found about low bushes and on tall grass. They are somewhat sluggish, and, therefore, easily caught.

The larvæ also are predaceous. Some live in earth,

decaying wood, or dry sand; others live in moss or in water. They have either two pairs of spiracles, one at each end of

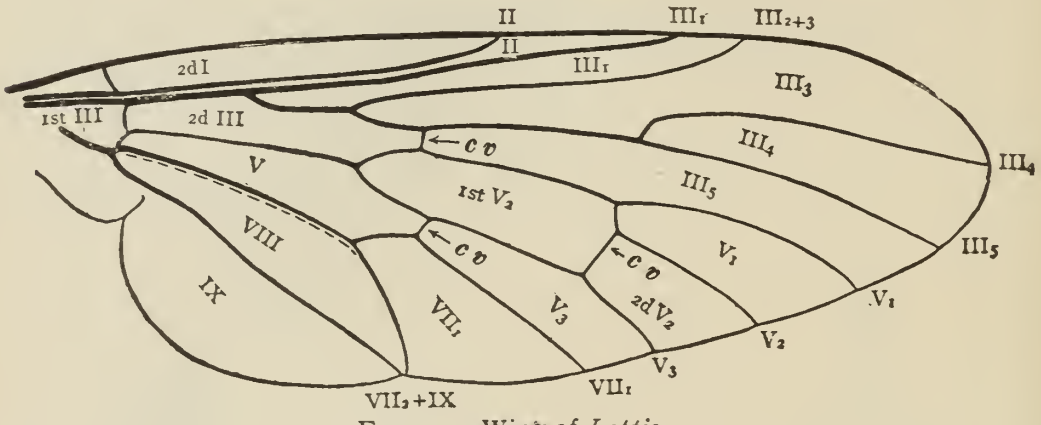

FIG. 551.—Wing of *Leptis*.

the body, or are furnished with tracheal gills. The last segment of the body has a transverse cleft, both above and

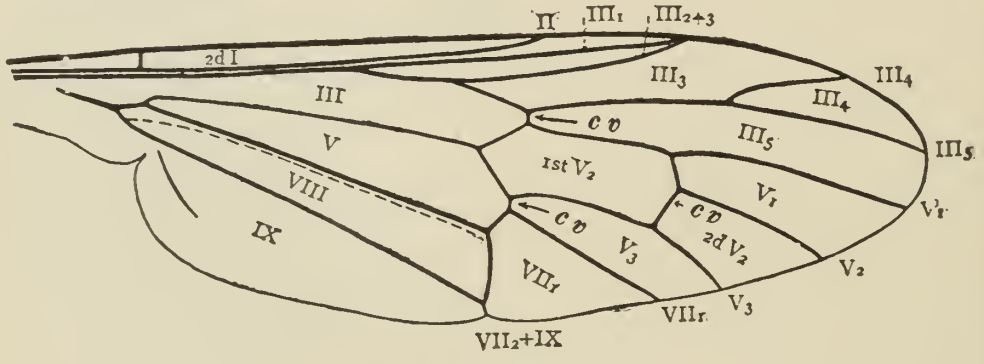

FIG. 552.—Wing of *Xylophagus*.

below, which is furnished above with two processes. The pupæ are free.

The family is of moderate size; about seventy North American species have been described.

Family ACROCERIDÆ (Ac-ro-cer'i-dæ).

The Small-headed Flies.

These flies are easily recognized by the unusually small head, the large humpbacked thorax, the inflated abdomen, and the very large alulets (Fig. 553).

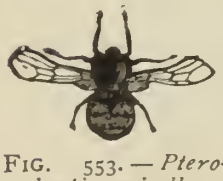

FIG. 553. — *Pterodontia misella.*

The head is composed almost entirely of eyes, and in some genera is minute. The

eyes are contiguous in both sexes. The antennæ are two- or three-jointed, and are furnished with a style or bristle in some genera, in others not. The venation of the wings varies greatly in the different genera. We are unable, therefore, to point out distinctive features drawn from these organs. The figure given (Fig. 554) represents a single genus rather than the family.

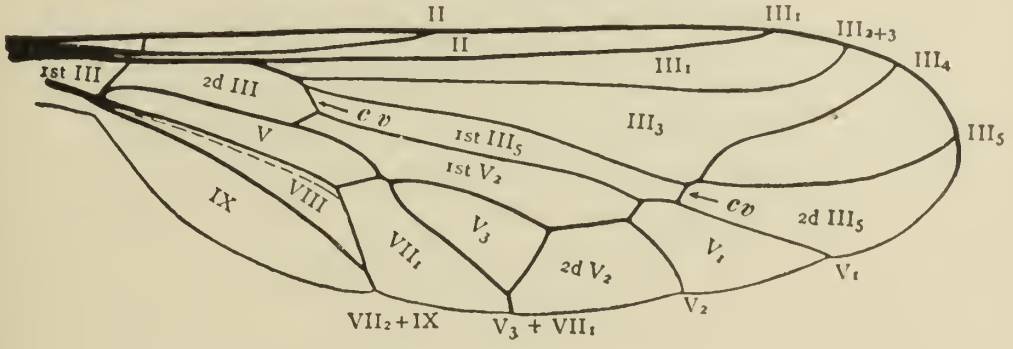

FIG. 554.—Wing of *Eulonchus*

The flies are generally slow and feeble in their movements. In some species that feed upon flowers the proboscis is very long, sometimes exceeding the body in length. Other species take no nourishment in the adult state, and have no proboscis. The empodia are pulvilliform.

"The larvæ are apparently chiefly parasitic, and in the few species in which they have been observed are parasitic on spiders or their cocoons, in the former cases the young larvæ living within the abdomen." (Williston.)

Family NEMISTRINIDÆ (Nem-is-trin′i-dæ).

The Tangle-veined Flies.

The members of this family are of medium size; some of them resemble horse-flies, and others bee-flies. They can be recognized by the peculiar venation of the wings, there being an unusual amount of anastomosing of the veins (Fig. 555), which gives the wings a very characteristic appearance.

The antennæ are small and short; the third segment is simple and furnished with a slender, jointed, terminal style. The proboscis is usually long, sometimes very long, and

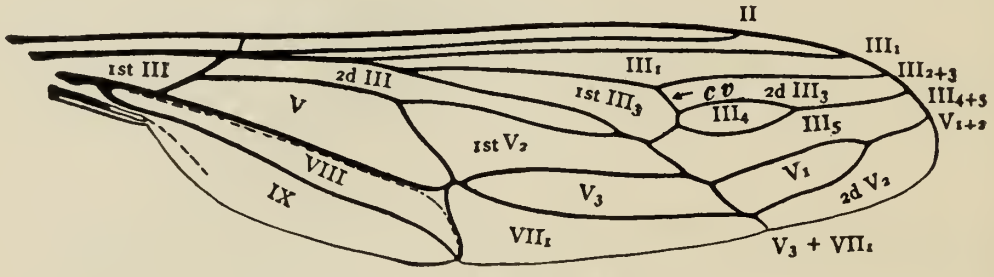

FIG. 555.—Wing of *Rhynchocephalus sackeni*.

fitted for sucking nectar from flowers. Only four North American species have been described; and these are all rare.

Family ASILIDÆ (A-sil'i-dæ).

The Robber-flies.

These are mostly large flies, and some of them are very large. The body is usually elongate, with a very long, slender abdomen (Fig. 556); but some species are quite stout, resembling bumblebees in form. This resemblance is often increased by a dense clothing of black and yellow hairs.

In this and the following family the vertex of the head

FIG. 556.—*Erax apicalis* destroying a cotton-worm. (From the Author's Report for 1879.)

FIG. 557.—Head of robber-fly.

FIG. 558.

is hollowed out between the eyes (Fig. 557). In this family the proboscis is pointed and does not bear fleshy lips at the

tip. The antennæ project forward in a prominent manner. They are three-jointed, and with or without a terminal style. The style when present sometimes appears like one or two additional segments (Fig. 558).

Vein III_4 (Fig. 559) does not curve forward toward the costal margin of the wing as in the following family. Cell V_3 is present, but is usually closed by the coalescence of the

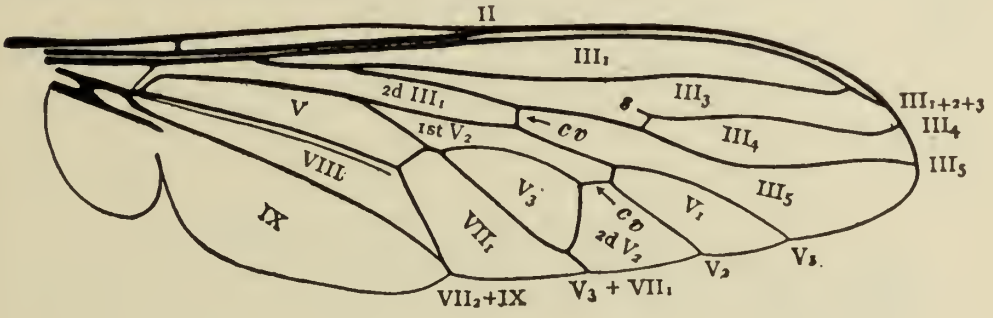

FIG. 559.—Wing of *Erax*.

tips of veins V_3 and VII_1. The tips of veins VII_2 and IX may or may not coalesce for a short distance. The robber-flies are extremely predaceous. They not only destroy other flies, but powerful insects, as bumblebees, tiger-beetles, and dragon-flies, fall prey to them; they will also feed upon larvæ. They are common in open fields and are as apt to alight on the ground as on elevated objects.

The larvæ live chiefly in the ground or in decaying wood, where they prey upon the larvæ of beetles; some, however, are supposed to feed upon the roots of plants. The pupæ are free.

The family includes a large number of genera and species.

Family MIDAIDÆ (Mi-da'i-dæ).

The Midas-flies.

The Midas-flies rival the robber-flies in size, and quite closely resemble them in appearance. As in that family, the vertex of the head is hollowed out between the

eyes; but these flies can be distinguished by the form of the proboscis, which bears a pair of fleshy lobes at the tip, by the form of the antennæ, which are long and clubbed at the tip (Fig. 560), and by the peculiar venation of the wings (Fig. 561), vein V_1 terminating at or before the apex of the wing, and the branches of vein III coalescing near the apex of the wing in an unusual way.

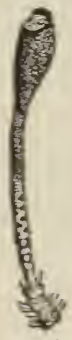

FIG. 560.

The adult flies are predaceous. The family is a small one; but a large proportion of the species occur on this continent.

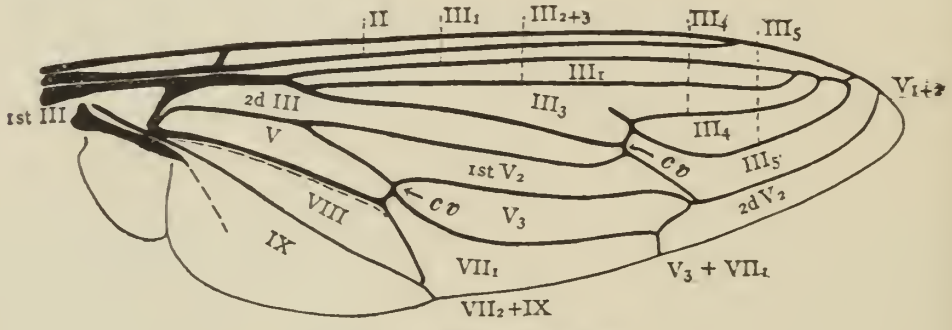

FIG. 561.—Wing of *Midas*.

Family APIOCERIDÆ (A-pi-o-cer'i-dæ).

The Apiocerids (A-pi-oc'e-rids).

This family includes only a small number of species,

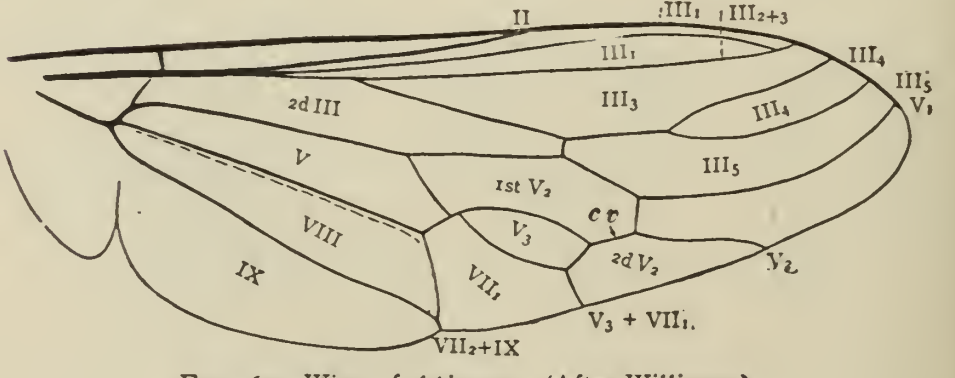

FIG. 562.—Wing of *Apiocera*. (After Williston.)

which are rare and occur in the far West. They are rather large and elongate, and are found upon flowers.

The head is not hollowed out between the eyes; the ocelli are present; the antennæ are furnished with a short, simple style. Vein III is usually four-branched, but sometimes it is only three-branched; all of the branches of vein III end before the apex of the wing (Fig. 562); cell V_3 is present, but closed by the coalescence of veins V_3 and VII_1 at the margin of the wing; and cell V_2 is divided by a cross-vein. The empodia are wanting.

Family BOMBYLIIDÆ (Bom-by-li'i-dæ).

The Bee-flies.

These flies are mostly of medium size, some are small, others are rather large. In some the body is short and broad and densely clothed with long, delicate hair (Fig. 563). Other species resemble the horse-flies somewhat in appearance, especially in the dark color or markings of the wings; but these can be distinguished from the horse-flies by the form of the antennæ and the venation of the wings.

FIG. 563.—*Bombylius.*

The antennæ are usually short; they are three-jointed; the third segment is not ringed; the style is sometimes present and sometimes wanting. The ocelli are present. The proboscis is sometimes very long and slender, and sometimes short and furnished with fleshy lips at the extremity.

Vein III of the wings (Fig. 564) is four-branched; cell III_3 is sometimes divided by a cross-vein; cell V_3 is obliterated by the coalescence of veins V_3 and VII_1; in a few genera cell V_1 is also obliterated by the coalescence of veins V_1 and V_2; cell VIII is narrowly open, or is closed at or near the border of the wing. The alulets are small or of moderate size.

The adult flies feed on nectar, and are found hovering over blossoms, or resting on sunny paths, sticks or stones; they rarely alight on leaves.

The larvæ are parasitic, infesting hymenopterous and lepidopterous larvæ and pupæ and the egg-sacs of Orthoptera. The pupæ are free.

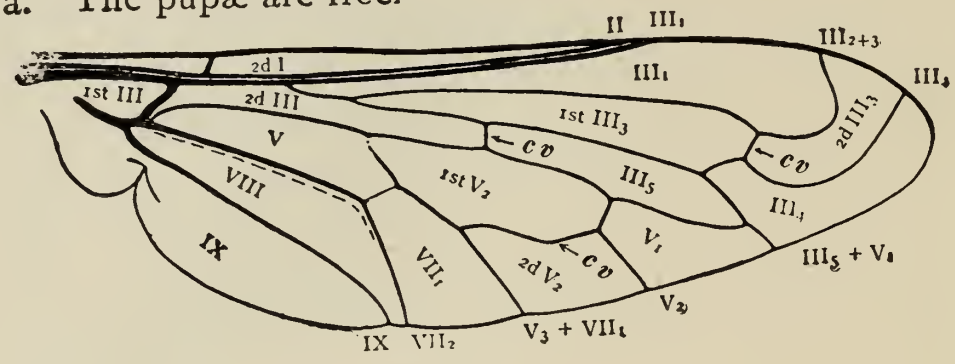

FIG. 564.—Wing of *Pantarbes capito*.

The family is a large one, including many genera and species.

Family THEREVIDÆ (The-rev'i-dæ).

The Stiletto-flies.

With the flies of this family the head is transverse, being nearly as wide as the thorax; and the abdomen is long and tapering, suggesting the name stiletto-flies. These flies are small or of medium size; they are hairy or bristly. The antennæ are three-jointed; the third segment is simple, and usually bears a terminal style; but this is sometimes wanting. Three ocelli are present. The legs are slender and bristly; the empodia are wanting.

Vein III of the wings (Fig. 565) is four-branched, and the last branch (vein III_5) terminates beyond the apex of the wing; the branches of vein V are all separate; cell VIII is closed near the border of the wing; the 2d cell III and cell V are long.

The adult flies are predaceous; and conceal themselves among the leaves of low bushes or settle on the ground in sandy spots, waiting for other insects upon which they prey.

The larvæ are long and slender, and the body is apparently composed of nineteen segments. They are found in

earth, fungi, and decaying wood. They feed on decaying animal and vegetable matter and are said to be predaceous also. The pupæ are free.

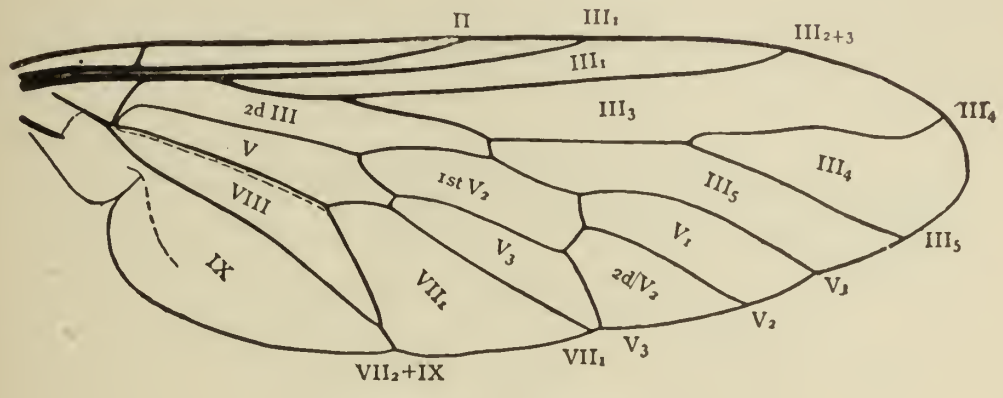

FIG. 565.—Wing of *Thereva*.

The family is a comparatively small one, including but few genera and species.

Family SCENOPINIDÆ (Scen-o-pin'i-dæ).

The Window-flies.

The window-flies are so-called because the best-known species are found almost exclusively on windows; but the conclusion that these are the most common flies found on windows should not be drawn from this name; for such is not the case.

These flies are of medium size, our most common species measuring one-fourth inch in length. They are usually black, and are not clothed with bristles. The thorax is prominent, and the abdomen is flattened and somewhat bent down, so that the body when viewed from the side presents a humpbacked appearance (Fig. 566). When at rest, the wings lie parallel, one over the other, on the abdomen; when in this position they are very inconspicuous. There are three ocelli. The antennæ are three-jointed; the first and second segments are short, the third is long and bears neither a style nor a bristle (Fig. 567).

FIG. 566.

FIG. 567.

Scenopinus.

The venation of the wings is represented by Figure 568. Vein III is four-branched; cells V_1 and V_2 are both obliterated by the coalescence of the veins that bound them; cell VIII is closed at a considerable distance before the margin; and the 2d cell III is much longer than cell V.

The larvæ, which are sometimes found in dwellings

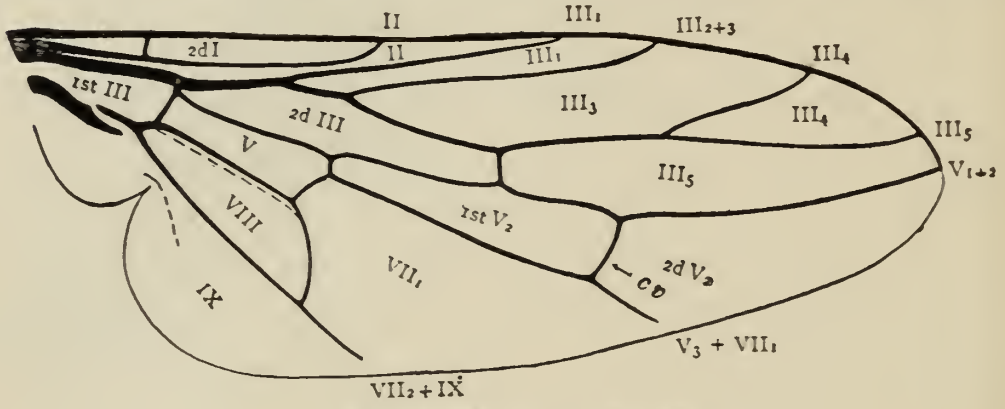

FIG. 568.—Wing of *Scenopinus*.

under carpets or in furniture, are very slender, and are remarkable for the apparently large number of the segments of the body, each of the abdominal segments except the last being divided by a strong constriction. They are also found in decaying wood, and are supposed to be carnivorous.

The family is a very small one. The most common species is *Scenopinus fenestralis* (Sce-nop'i-nus fen-es-tra'lis).

Family EMPIDIDÆ (Em-pid'i-dæ).

The Dance-flies.

The dance-flies are of medium or small size; they are often seen in swarms under trees or near shrubs and about brooks, dancing and hunting. The family is a rather difficult one to characterize owing to great variations in the form of the antennæ and in the venation of the wings.

The branches of vein VII coalesce with the adjacent veins (VII_1 with V_3 and VII_2 with IX) from the margin of the wing towards the base for a considerable distance (Fig. 569). In most of the genera this coalescence is carried so far that the free parts of the branches of vein VII appear

like cross-veins. The only other families of the suborder Orthorrhapha in which this occurs are the two following; and the venation of the wings in each of these is very different from that of the Empididæ.

The antennæ are three-jointed; the first and second

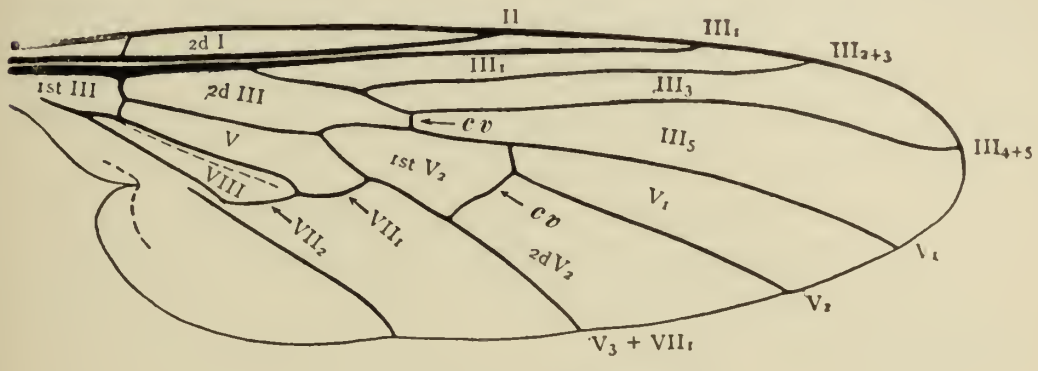

FIG. 569.—Wing of *Rhamphomyia.*

segments are often very small, and then appear like a single segment; the third segment may or may not bear a style or bristle. The mouth-parts are in many cases long, and extend at right angles to the body or are bent back upon the breast.

These flies are predaceous, like the robber-flies; but they also frequent flowers. The larvæ live in decaying vegetable matter, but are probably carnivorous. The pupæ are free. The family is a large one, containing many genera and species.

Family DOLICHOPODIDÆ (Dol-i-cho-pod'i-dæ).

The Long-legged Flies.

These flies are of small or medium size and usually bright metallic green in color. The legs are much longer than is usual in the families belonging to the series of short-horned flies (Fig. 570). This suggested the name *Dolichopus* (Do-lich'o-pus), which means long-footed, for the typical genus; and from this the family name is derived. It should be

FIG. 570.—*Dolichopus lobatus.*

remembered, however, that these flies are long-legged in comparison with the allied families, and not in comparison with crane-flies and midges.

The members of this family are easily distinguished as such by the peculiar venation of the wings, the most characteristic features of which are the following (Fig. 571): cells V and 1st V_2 are not separated by a vein, the basal part of vein V_3 being undeveloped; veins III_{2+3} and III_{4+5} separate near the base of the wing, and the two veins form

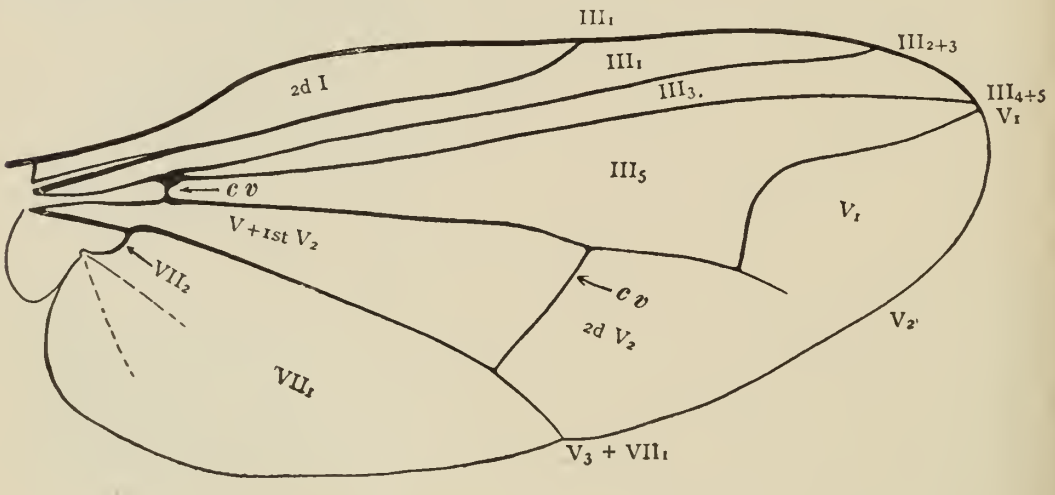

Fig. 571.—Wing of *Psilophus ciliatus*.

at the point of separation a more or less knot-shaped swelling; the cross-vein III–V is at or close by this swelling, so that cell III is very short. A somewhat similar venation occurs in some of the Muscidæ; but there the knot-shaped swelling on vein III is often wanting, and the cross-vein III–V is usually more remote from the base of the wing; and too the flies belonging to the Muscidæ possess the suture above the antennæ characteristic of the suborder Cyclorrhapha.

The members of this family have three ocelli; the antennæ are three-jointed; the second segment of the antenna is sometimes rudimentary; and the third segment bears a two-jointed arista.

The adults are predaceous and hunt for smaller flies and

other soft-bodied insects. They are usually found in damp places, covered with rank vegetation. Some species occur chiefly on the leaves of aquatic plants, and about dams and waterfalls; and some are able to run over the surface of water. Others occur in dry places.

The larvæ live in earth or decomposing vegetable matter. They are long, slender, and cylindrical, and have two pairs of spiracles, one at each end of the body. In most cases the pupæ are free; but some form cocoons. The thorax of the pupa bears a pair of long breathing-tubes.

The family is a large one; more than two hundred North American species have been described already.

Family LONCHOPTERIDÆ (Lon-chop-ter'i-dæ).

The Spear-winged Flies.

These are minute flies, which measure from one twelfth to one sixth of an inch in length, and are usually brownish or yellowish. When at rest the wings are folded flat, one over the other, on the abdomen. The apex of the wing is pointed; and the wing as a whole is shaped somewhat like the head of a spear. This suggested the family name.

The venation of the wings is very characteristic, and is sufficient to distinguish these flies from all others. The

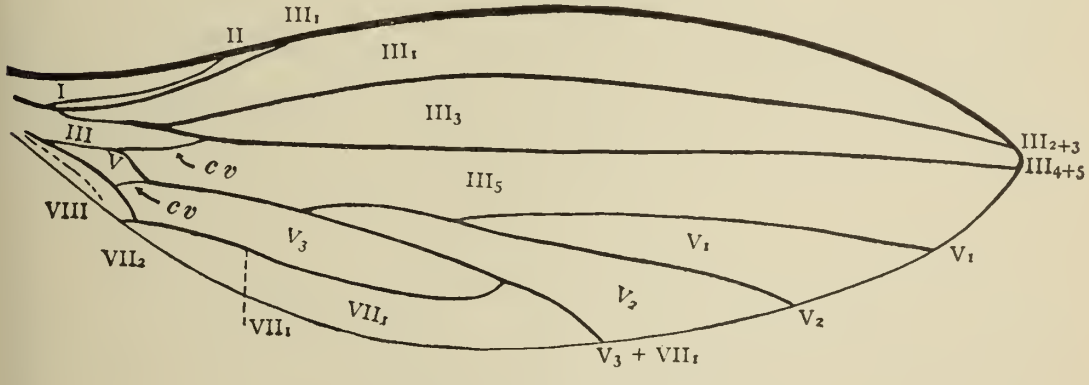

FIG. 572.—Wing of *Lonchoptera.*

cross-veins III–V and V–VII are oblique, and near the base of the wing (Fig. 572). Vein VII_2 is very short, and extends towards the base of the wing. In the females vein

VII_1 coalesces with vein V_3, as shown in the figure; but in the males the tip of vein VII_1 is free. The posterior lobe is wanting.

Three ocelli are present. The antennæ are three-jointed; the third segment is globular, and bears a three-jointed style.

These flies are common from spring till autumn, in damp grassy places. They frequent the shores of shady brooks, where the atmosphere is moist. But little is known as yet about their habits and tranformations.

In the shape of the wings, the absence of cross-veins, except at the base of the wing, and the great reduction of the anal area of the wing the flies closely resemble the Psychodidæ.

Suborder CYCLORRHAPHA (Cy-clor'rha-pha).

The Circular-seamed Flies.

To this suborder belong those families of flies in which the pupa escapes from the larval skin through a round opening made by pushing off the head-end of it (Fig. 573). The pupa is always enclosed in a puparium. The adult flies possess a frontal lunule (see footnote page 461), and except in the first four families a frontal suture, through which the ptilinum is pushed out, when the adult is about to emerge from the puparium (see page 419).

FIG. 573.—Puparium of a Muscid.

Family SYRPHIDÆ (Syr'phi-dæ).

The Syrphus-flies.

The family Syrphidæ includes many of our common flies; but the different species vary so much in form that no general description of their appearance can be given. Many of them mimic hymenopterous insects; thus some species resemble bumblebees, others the honey-bee, and still others wasps; while some present but little resemblance to any of these.

The most distinctive characteristic of the family is the presence of a thickening of the membrane of the wing, which appears like a longitudinal vein between veins III and V. This is termed the *spurious vein*, and is lacking in only a few members of the family ; it is represented in Figure 574 by a

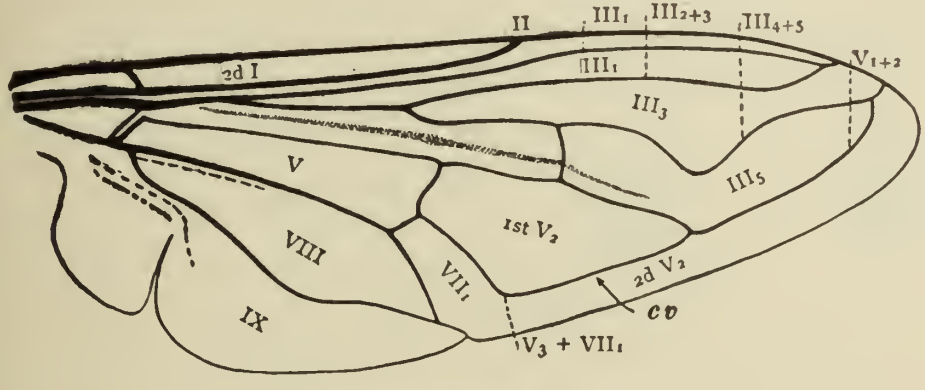

FIG. 574.—Wing of *Eristalis*.

band of stippling. Cell III_5 is closed ; and the 2d cell III and cell V are large.

The antennæ are three-jointed ; the third segment usually bears a dorsal bristle, but sometimes it is furnished with a thickened style. The face is not furnished with longitudinal furrows to receive the antennæ as in the Muscidæ. The frontal lunule is present, but the frontal suture is wanting.

The adults frequent flowers and feed upon honey and pollen. Some fly with a loud humming sound like that of a bee ; others hover motionless except as to their wings for a time, and then dart away suddenly for a short distance, and then resume their hovering.

The larvæ vary greatly in form and habits. Some prey upon plant-lice, and are often found in the midst of colonies of these insects ; others feed on decaying vegetable matter, and live in rotten wood, in mud, and in water. Some are found in the nests of ants ; and some in the nests of bumblebees and of wasps.

Among the common representatives of this family there is one that so closely resembles a male honey-bee as to be

often mistaken for it. This is the Drone-fly, *Eristalis tenax* (E-ris'ta-lis te'nax). It is common about flowers. The larva lives in foul water, where it feeds on decaying vegetable matter; it is of the form known as "rat-tailed," which is described below.

The larvæ of the genus *Volucella* (Vol-u-cel'la) are predaceous, living in the nests of bumblebees and of wasps (*Vespa*), and feeding upon their larvæ. Some of the species in the adult state very closely resemble bumblebees.

FIG. 575.—*Microdon*, adult and larva.

The larvæ of the genus *Microdon* (Mic'ro-don) are hemispherical, slug-like creatures (Fig. 575), which resemble mollusks more than ordinary maggots; they are common in ants' nests.

The larvæ of several species that live in water as well as some that live in rotten wood are known as rat-tailed maggots on account of a long, tail-like appendage, with which the hind end of the body is furnished. This is a tube, like that of a diver, which enables the insect to obtain air when its body is submerged beneath several inches of water or decaying matter. This tube being telescopic can be lengthened or shortened as the insect may need it; and at its tip there is a rosette of hairs, which, floating on the surface of the water, keeps the tip from being submerged. The larva has on the ventral side of its body several pairs of tubercles armed with spines, which serve as prolegs.

Among the more common members of this family are the yellow-banded species belonging to the genus *Syrphus* (Syr'phus) (Fig. 576). The larvæ of these live in colonies of Aphids, and do much good by destroying these pests.

FIG. 576.—*Syrphus.*

This family is a very large one; nearly or quite two thousand species being known. In his monograph of the species of America north of Mexico,

Professor Williston describes about three hundred species from this region.*

Family PIPUNCULIDÆ (Pip-un-cu'li-dæ).

The Big-eyed Flies.

This family is represented in the United States by a single genus, *Pipunculus* (Pi-pun'cu-lus). These are small flies, with very large heads composed almost entirely of eyes (Fig. 577). The head is nearly spherical, and broader than the thorax. The abdomen is somewhat elongate with the sides nearly parallel. The body is thinly clothed with hair or nearly naked. The wings are much longer than the abdomen, and when at rest they lie parallel to each other upon it. The venation (Fig. 578) closely resembles that of some of the Conopidæ. Vein III is three-branched. The last branch of Vein III and

FIG. 577.—*Pipunculus.*

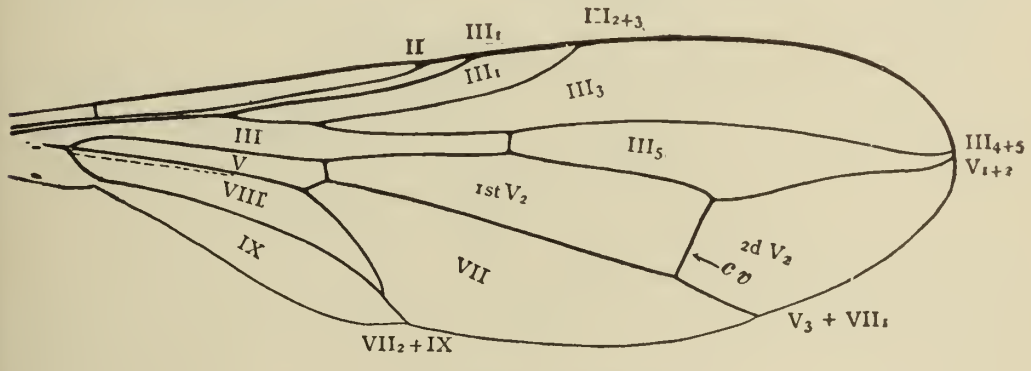

FIG. 578.—Wing of *Pipunculus.*

the first branch of vein V approach each other at their tips. Vein V_3 coalesces with vein VII_1 for nearly its entire length. Veins VII_2 and IX coalesce at their tips. Cells III and V are long.

The flies hover in shady places. They are sometimes found on flowers, and may be swept from low plants; our most common species measure about one eighth of an inch in length, not including the wings. The larvæ so far as known are parasitic upon bugs.

* Bulletin of the U. S. National Museum, No. 31.

Family PLATYPEZIDÆ (Plat-y-pez'i-dæ).

The Flat-footed Flies.

These flies resemble the House-fly somewhat in appearance but are very much smaller. They hover in the air in shady places, and alight frequently on the leaves of low plants, where they run about in circles with great rapidity.

The head is hemispherical or spherical, and as broad as or broader than the thorax. The antennæ are three-jointed, with a terminal bristle. The legs are short and stout, and the tarsi of the hinder pair are often very broad and flat (Fig. 579). The wings are rather large, and when at rest lie parallel upon the abdomen; the axillary excision is prominent, but the posterior lobe of the wing is small (Fig. 580); the alulets are minute.

FIG. 579.—Leg of *Platypeza*. *a*, forked hairs of leg greatly enlarged.

Vein III of the wings is three-branched; veins V_1 and V_2 either coalesce throughout or separate near the margin of the wing. Cell V_2 is sometimes divided

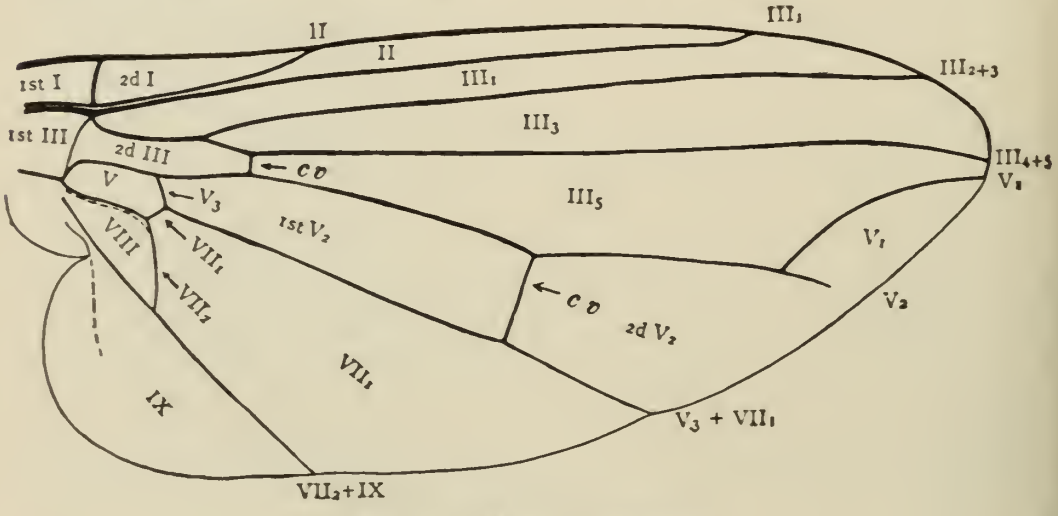

FIG. 580.—Wing of *Platypeza*.

by a cross-vein, and sometimes not. Cells 2d III, V, and VIII are short.

This family includes but few species, and these are usually rare. The larvæ live in rotten mushrooms.

Family PHORIDÆ (Phor'i-dæ).

The Humpbacked Flies.

These are minute, dark-colored, usually black flies, which can easily be recognized by their humpbacked form and the peculiar venation of the wings. Certain species are often found running about rapidly on windows, others on fallen leaves. Sometimes they are seen in swarms dancing up and down in the air.

The head is small; the thorax large and humped; and the abdomen rather short. The antennæ are apparently

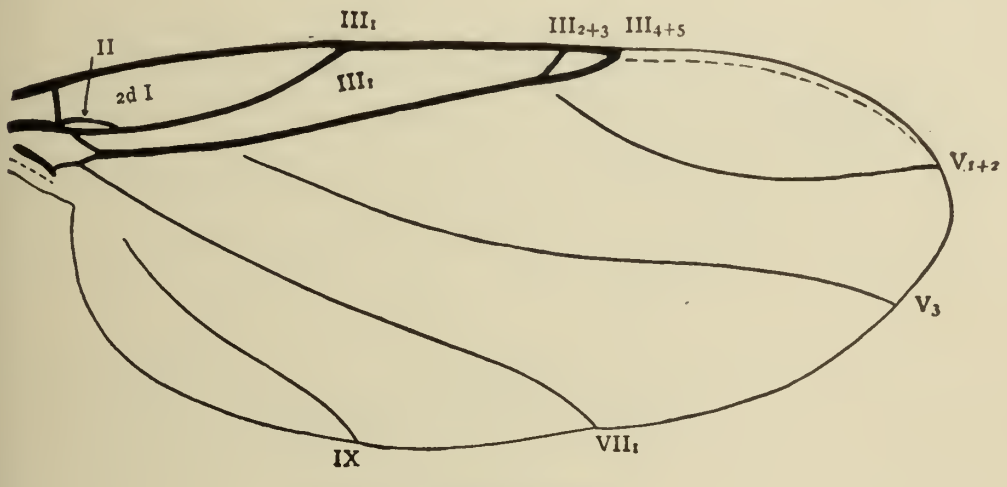

FIG. 581.—Wing of *Phora*.

one- or two-jointed, the last segment with either a dorsal or a terminal bristle. The coxæ are long; the femora, especially of the hind legs, which are rather long, are widened and flattened. The wings (Fig. 581) are large, and are furnished with two strong veins near the costal border, which extend but a short distance beyond the middle of the wing. From these strong veins from three to five weak ones extend across the wing.

The larvæ feed on decaying vegetable matter, dead insects, snails, etc., and some are believed to be parasitic upon other insects.

Family CONOPIDÆ (Co-nop'i-dæ).

The Thick-head Flies.

With the members of this family the head is large, being broader than the thorax. The body is more or less elongate; sometimes the abdomen has a long, slender pedicel like that of certain wasps. The body may be naked or thinly clothed with fine hair, but it is rarely bristly.

The ocelli may be either present or absent. The antennæ are prominent, and project forward; they are three-jointed; and the third segment bears either a dorsal bristle

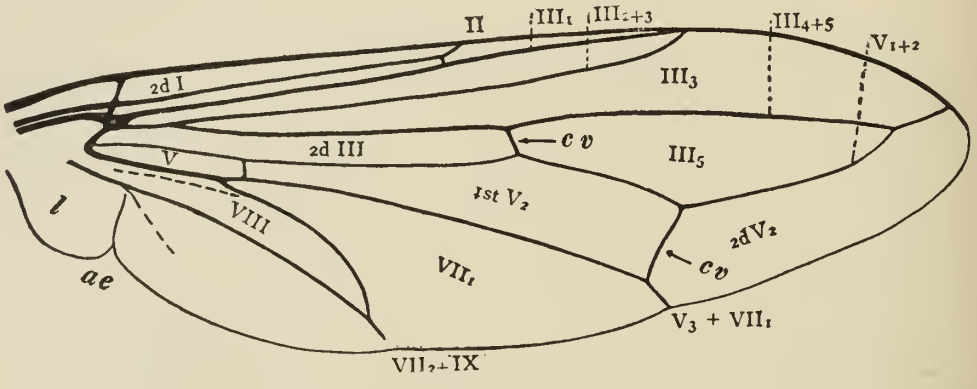

FIG. 582.—Wing of *Conops affinis*.

or a terminal style. Vein III of the wings (Fig. 582) is only three-branched. The last branch of vein III and the first branch of vein V end near together or coalesce at their tips. Cell V_2 is divided by a cross-vein. Vein V_3 coalesces with vein VII_1 for nearly its entire length. Veins VII_2 and IX coalesce at their tips, and sometimes for nearly the entire length of vein VII_2.

FIG. 583.—*Conops*.

The adult flies are found on flowers. In some genera the abdomen is long, with a slender, wasp-like pedicel (Fig. 583). In others the abdomen is of the more usual form. The larvæ are parasitic, chiefly upon bumblebees and wasps, but some species infest locusts.

Family ŒSTRIDÆ (Œs'tri-dæ).

The Bot-flies.

This family includes flies that are large or of medium size; most of the species resemble bees in appearance; some, the honey-bee; others, bumblebees. In the venation of the wings they closely resemble the Muscidæ; but the wings are usually furnished with fine transverse wrinkles. They are most easily distinguished from the Muscidæ by the small size of the opening of the mouth and the rudimentary condition of the mouth-parts, the proboscis being rudimentary and the palpi usually wanting.

The head is large, with the face broad. The antennæ are small, three-jointed, more or less concealed in a subantennal cavity or grooves; the last segment bears a dorsal bristle. Vein III of the wings is three-branched. Cell III_6 is broadly open (Fig. 584), or is narrowed at the margin of

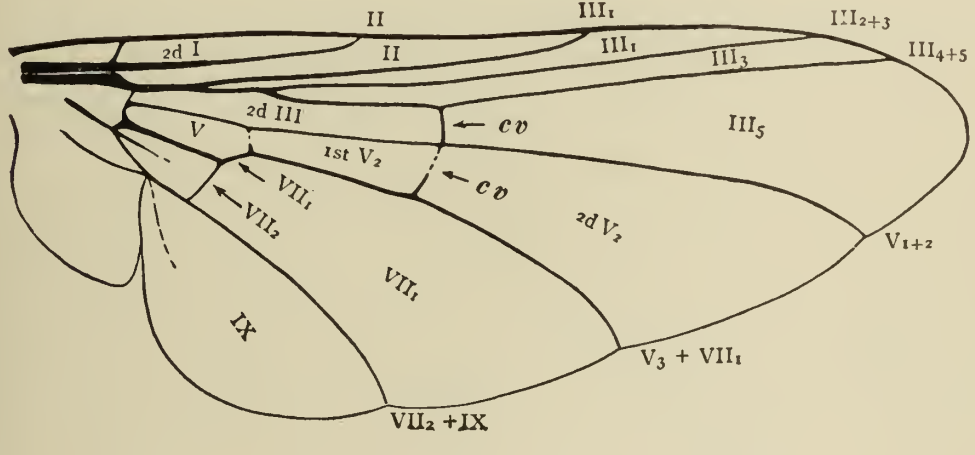

FIG. 584.—Wing of *Gastrophilus*.

the wing, or closed. The alulets are usually large, concealing the halteres; but sometimes they are small.

The larvæ are parasitic upon mammals. The best known species are the following:

The Horse Bot-fly, *Gastrophilus equi* (Gas-troph'i-lus e'qui).—The adult fly closely resembles the honey-bee in

form except that the female (Fig. 585) has the end of the abdomen elongate and bent forward under the body. It is most often seen flying about horses, which have an instinctive fear of it. The eggs are attached to the hair, chiefly on the legs and shoulders of the horse. The larvæ are licked off by the horse and swallowed with its food. When the larvæ reach the stomach they fasten themselves to the inner coat of it, and remain there until full-grown. Then they pass from the animal with the dung, and crawl into some protected place, where they transform within a puparium.

FIG. 585.

The Oxwarble, *Hypoderma lineata* (Hyp-o-der′ma lin-e-a′ta).—The larva of this species is the common pest that lives in the backs of cattle just beneath the skin. The adult lays its eggs on the backs of cattle; and it has been supposed that the young larvæ penetrate the skin, thus reaching the place where they are commonly found. But Dr. Cooper Curtice has recently shown that the larvæ are licked off from the back by the cattle and swallowed. He found the larvæ in large numbers in the walls of the œsophagus in November; later, about Christmas-time, they appeared suddenly, and in large numbers under the skin of the back. The course of their migration from the œsophagus to the skin has not yet been traced. The greater part of the growth of the larva is made within the tumor beneath the skin. When full-grown it passes out through a hole in the skin and undergoes its transformations on the ground. Dr. Curtice has also shown that the most common oxwarble of this country is *Hypoderma lineata* and not *Hypoderma bovis*, as has been supposed.

The Sheep Bot fly, *Œstrus ovis* (Œs′trus o′vis).—The eggs of this species are laid in the nostrils of sheep. The larvæ pass up into the frontal sinuses and into the horns when they are present. Here they feed upon the mucus. They are very injurious to sheep, causing vertigo or the

disease known as "staggers." When full-grown they pass out through the nostrils and undergo their transformations beneath the surface of the ground.

Other species infest rabbits, squirrels, deer, and reindeer. One that lives beneath the skin of the neck of rabbits is very common in the South.

Family MUSCIDÆ (Mus'ci-dæ).

The Muscids (*Mus'cids*).

The form of the more typical members of this family is well shown by the common House-fly. But the family is a very large one and includes species that differ greatly in form. These differences are so great and so varied that some writers divide the family into nearly thirty families. It seems to us, however, to be better to consider these divisions of subfamily value. The following characters are presented by the family as a whole.

The antennæ (Fig. 586) are three-jointed; the third segment bears a dorsal bristle. The frontal suture is present (Fig. 587). The proboscis is always present. Vein II of the wings may be present or absent; vein III is three-branched; cells V_1 and V_3 are wanting; the branches of vein VII coalesce with the adjacent veins (VII_1 with V_3, and VII_2 with IX) for nearly their entire length. The pulvilli are present, and the empodia are never pulvilliform.

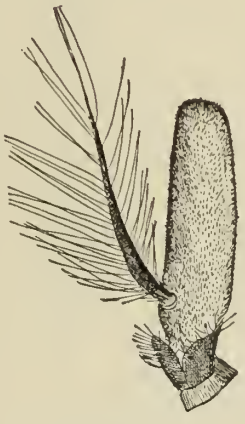

FIG. 586.

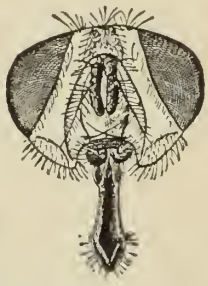

FIG. 587.

As this family includes more than one third of all the known Diptera, it usually happens that a large proportion of the flies in a collection belong to it. It seems necessary, therefore, to indicate some of the principal divisions of the

family. The first of these is into two groups of subfamilies, and is based upon the size of the alulets. The division is not a satisfactory one; and it is only given here because it is commonly employed by writers on the Diptera, and a more definite one has not yet been discovered.

A. The alulets large; face with a depression or vertical grooves beneath the antennæ; cell III_5 closed or narrowly open, except in the Anthomyiinæ, where it is widely open. p. 480.
CALYPTRATE MUSCIDÆ.

AA. The alulets small or wanting; form of face varied; cell III_5 usually widely open. p. 484.....ACALYPTRATE MUSCIDÆ.

I. CALYPTRATE MUSCIDÆ (Ca-lyp'trate).

To this division belong our most familiar representatives of the family, of which the House-fly and the flesh-flies are good illustrations. As a rule cell III_5 of the wings is closed or narrowly open (Fig. 588); but in the last subfamily this

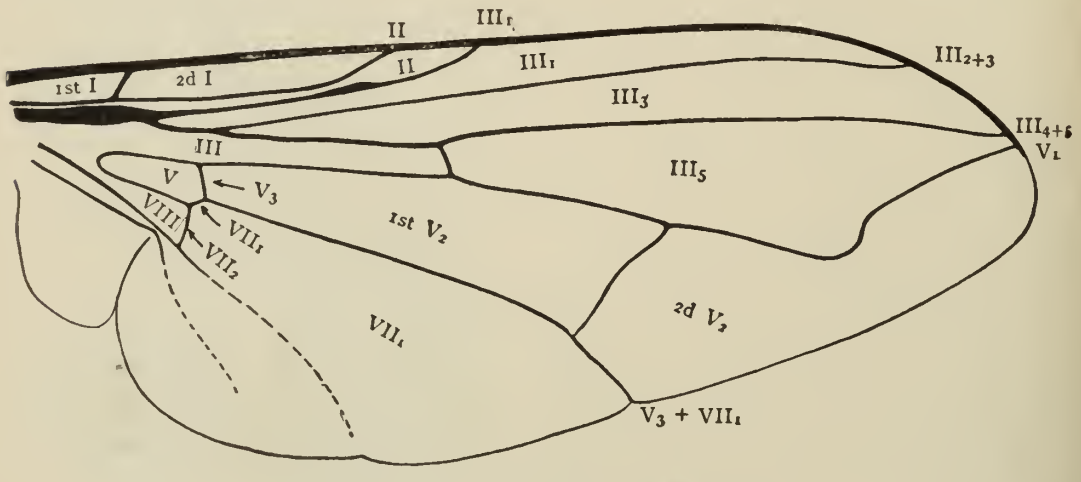

FIG. 588.—Wing of *Musca domestica*.

cell is widely open (Fig. 589). Five subfamilies are classed here; these can be separated by the following table, which is based on one given by Professor Williston.

A. Cell III_5 of the wings closed or more or less narrowed at the margin of the wing (Fig. 588).
B. Antennal bristle wholly bare. p. 481.....TACHININÆ.
BB. Antennal bristle distinctly pubescent or plumose.

C. Antennal bristle bare near the tip. p. 482. . SARCOPHAGINÆ.
CC. Antennal bristle plumose or pubescent to the tip.
D. Dorsum of abdomen bristly; legs usually elongate. p. 482. DEXIINÆ.
DD. Abdomen not bristly, except sometimes somewhat so near the tip. p. 482 ..... MUSCINÆ.
AA. Cell III_5 widely open, not narrowed at the margin of the wing (Fig. 589). p. 483 ..... ANTHOMYIINÆ.

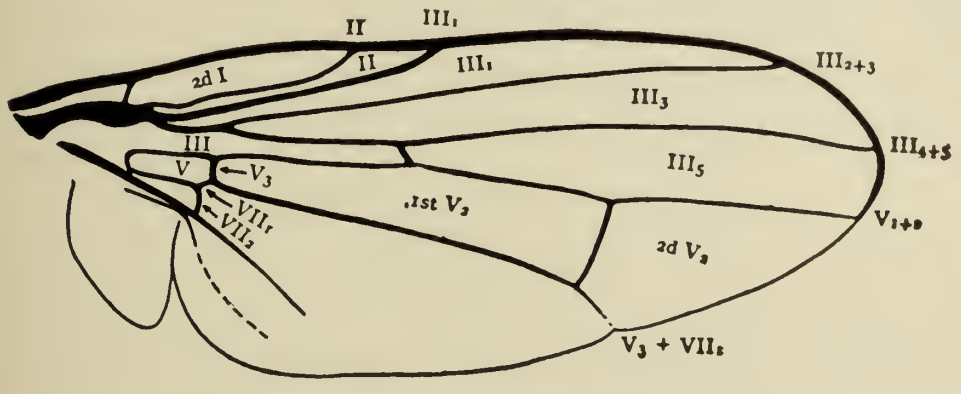

FIG. 589.—Wing of *Lispe*.

Subfamily TACHININÆ (Tach-i-ni'næ).

The Tachina-flies (*Ta-chi'na*).

The Tachina-flies are often found about flowers and rank vegetation. They are usually short, stout, and bristly, and can be distinguished from the three following subfamilies by the bristle of the antennæ being wholly bare.

The larvæ are parasitic, chiefly within caterpillars, and play an exceedingly important part in checking the increase of noxious insects. The female fastens her eggs to the skin of a caterpillar (Fig. 590); when the larvæ hatch they bore their way into their host and live there till they are full-grown.

FIG. 590. — *Nemoræa leucaniæ*. Larva, adult, puparium, and eggs upon fore part of an army-worm. (From the author's Report for 1879.)

Subfamily SARCOPHAGINÆ (Sar-coph-a-gi'næ).

The Flesh flies.

These flies resemble those of the preceding subfamily in general appearance, but differ in having the bristle of the antenna plumose or hairy at the base; the outer end of the bristle is bare. They are called flesh-flies because many of them lay their eggs on the bodies of dead animals, resembling in habits the Blow-fly, which belongs to the subfamily Muscinæ. The larvæ of other species live in dung, in decaying vegetable matter, and in fruits.

Subfamily DEXIINÆ (Dex-i-i'næ).

The Nimble-flies.

In this subfamily the bristle of the antenna is plumose or bristly to the tip, and the dorsum of the abdomen is bristly. The legs are usually long. These flies are much less common than the members of the allied subfamilies; the larvæ of some of the species, at least, are parasitic.

Subfamily MUSCINÆ (Mus-ci'næ).

The Typical Muscids (Mus'cids).

With these flies, as in the preceding subfamily, the bristle of the antenna is pubescent or plumose to the tip; but the abdomen is not bristly except near the tip. Here belong many of the best-known members of the Muscidæ; among the more important ones are the following:—

The House-fly, *Musca domestica* (Mus'ca do-mes'ti-ca).—This is the most familiar representative of the order Diptera, as it abounds in our dwellings. It lays its eggs in horse-manure, a single female laying from one hundred and twenty to one hundred and sixty eggs; the larvæ become full-grown in from five to seven days, having molted twice; the pupa state lasts from five to seven days.

The Stable-fly, *Stomoxys calcitrans* (Sto-mox'ys cal'ci-trans).—This species resemble the House-fly in appearance;

but it has its mouth fitted for piercing and for sucking blood. It annoys cattle greatly; and before storms and in the autumn it enters our dwellings and attacks us. The larvæ live in fresh horse-manure.

The Horn-fly, *Hæmatobia serrata* (Hæm-a-to′bi-a ser-ra′ta).—This is an exceedingly annoying pest of horned cattle, which has spread over the United States in recent years. It resembles the House-fly in appearance; but is less than half as large. These flies cluster in great numbers around the base of the horns; they also settle upon the back. The larvæ live in fresh cow-manure.

The Screw-worm Fly, *Campsomyia macellaria* (Camp-so-my′i-a mac-el-la′ri-a), is a bright metallic-green fly, with four black stripes on the upper part of the thorax; it measures about one third of an inch in length. This terrible pest resembles the flesh-flies in habits, and it deposits its eggs in wounds, sores, and the nostrils and ears of men and cattle. The larvæ living in these situations often cause serious sickness, and sometimes even death.

The Blow-fly, *Calliphora vomitoria* (Cal-liph′o-ra vom-i-to′ri-a), is larger than the House-fly, and black in color, with a steel-blue abdomen. It flies with a loud buzzing noise, and lays its eggs upon meat, cheese, and other provisions. The eggs hatch in about twenty-four hours, and the larvæ become full-grown in a few days.

Subfamily ANTHOMYIINÆ (An-tho-my-i-i′næ).

The Anthomyiids (*An-tho-my′i-ids*).

The members of this subfamily differ from other Calyptrate Muscidæ in having cell III_5 widely open, vein V_{1+2} nearly straight (Fig. 589), and not bent in its outer part towards the tip of vein III_{4+5}, as in the preceding subfamilies. In fact, the type of venation is the same as that which is characteristic of nearly all of the Acalyptrate Muscidæ; and as the alulets are quite small in some of the Anthomyiids, it is difficult for the beginner to recognize all

members of this family as such. It is to be hoped that other characters than those we now know for separating the Calyptrate Muscidæ from the Acalyptrate Muscidæ will soon be discovered.

The Anthomyiids are very common flies. They are found on leaves and flowers, and are also often found on windows in our dwellings. The larvæ of most species live in decaying vegetable matter, a few are parasitic on other insects, and some attack growing plants. Among the latter are certain well-known pests infesting garden crops. The more important of these are the following:—

The Cabbage-root Maggot, *Phorbia brassicæ* (Phor'bi-a bras'si-cæ).—This insect in its larval state feeds on the roots of cabbage, radish, turnip, and cauliflower; it also attacks the roots of various weeds belonging to the same family of plants. It is one of the most serious pests that gardeners have to contend with.

The Onion-fly, *Phorbia ceparum* (P. ce-pa'rum).—The larva of this species is often exceedingly destructive to onions, consuming the bulb of the plant.

The leaves of beet are often mined by maggots; and it has been found that this injury is due to several species of Anthomyiids. The most common of these is *Pegomyia vicina* (Peg-o-my'i-a vi-ci'na).

II. Acalyptrate Muscidæ (Ac-a-lyp'trate).

To this division of the Muscidæ belong a very large number of common flies. These vary greatly in form, and represent a large number of distinct subfamilies. As a rule cell III_5 of the wings is widely open (Fig. 591), and vein II may be either present or wanting. The alulets are usually very small or rudimentary.

The American species have not yet been sufficiently studied to enable us to give a table for separating the subfamilies. We will merely refer, therefore, to a few of the more important species.

The Dung-flies, *Scatophaga* (Sca-toph′a-ga), are rather

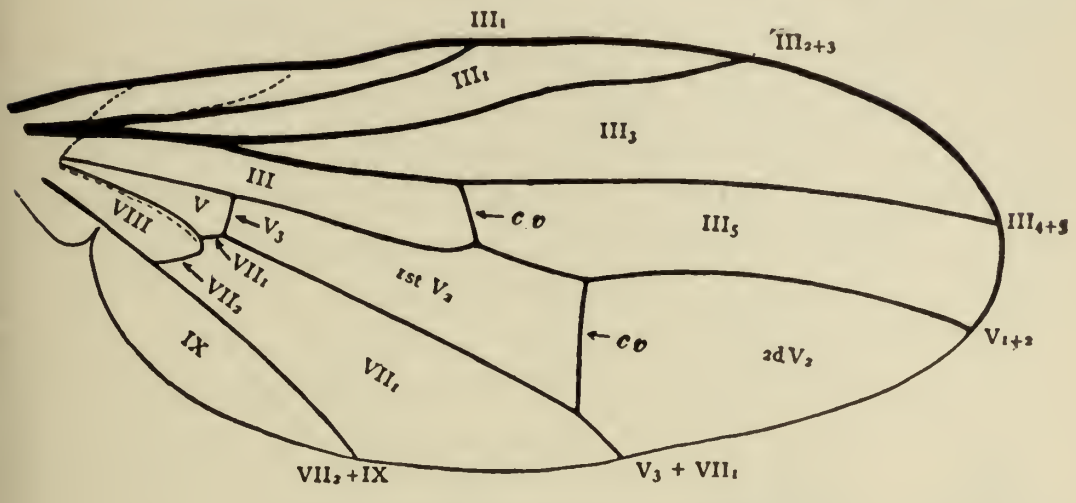

FIG. 591.—Wing of *Callopistria annulipes.*

slender flies, which have the body clothed with yellowish hair, and which are common, especially about fresh cow-dung. They belong to the Subfamily *Cordylurinæ* (Cor-dyl-u-ri′næ).

To the subfamilies *Ortalinæ* (Or-ta-li′næ) and *Trypetinæ* (Try-pe-ti′næ) belong many common species which have the wings beautifully marked with dark spots or bands. In the Ortalinæ vein II extends to the margin of the wing in the usual way; in the Trypetinæ the outer part of vein II turns suddenly towards the margin of the wing, and at the same time becomes much less dis-

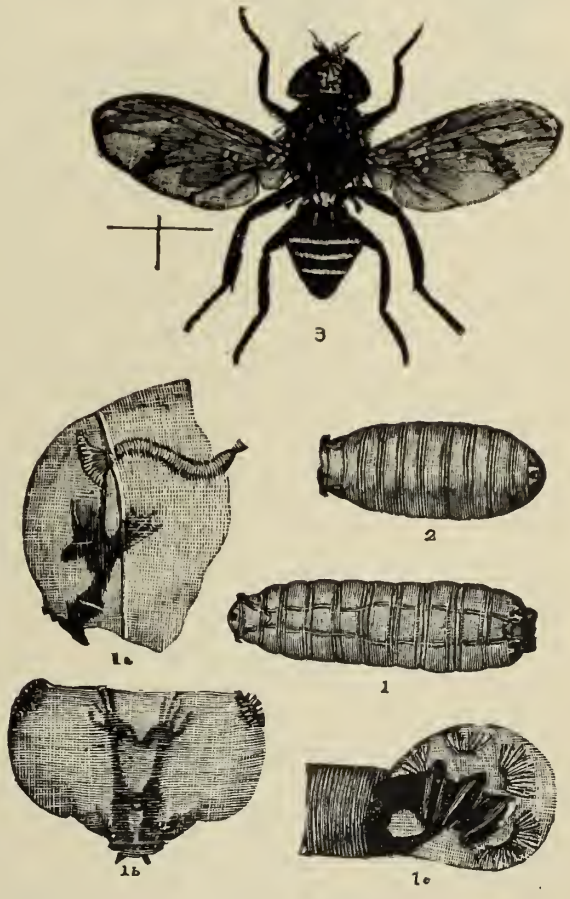

FIG. 592.—The Apple-maggot; 1, larva; 2, puparium; 3, adult; 1a, head of larva from side, showing mouth-parts and cephalic spiracle; 1b, head of larva from below; 1c, caudal spiracle of larva.

tinct. The two following are well-known members of the Trypetinæ.

The Apple-maggot, *Trypeta pomonella* (Try-pe'ta pom-o-nel'la.)—This maggot eats into the pulp of apples, boring tunnels in all directions through the fruit; it attacks especially the early maturing varieties. When full-grown it goes into the ground to transform. The adult is a black and white fly, with banded wings (Fig. 592).

The Round Goldenrod Gall.—One of the most familiar of abnormal growths on plants is a ball-like enlargement of the stem of goldenrod (Fig. 593). This is caused by a maggot, which lives within it, and which develops into a pretty fly with banded wings. This is *Trypeta solidaginis* (T. Sol-i-dag'i-nis). There is another gall on the stem of goldenrod which is liable to be mistaken for this one, but which can be easily distinguished from it. It is more elongate, and is hollow. It is made by the larva of a Tineid moth, *Gelechia gallæsolidaginis* (Ge-le'chi-a gal-læ-sol-i-dag'i-nis); it may be called the Elliptical Goldenrod Gall.

FIG. 593.—The Round Goldenrod Gall.

The Stem-eyed Fly, *Sphyracephala brevicornis* (Sphyr-a-ceph'a-la brev-i-cor'nis) is a very singular fly, which is found on the leaves of skunk-cabbage. On each side of the head there is horn-like process extending outward, upon the end of which the eye is situated. This species is the only American representative of its subfamily, the *Diopsinæ* (Di-op-si'næ), yet described.

The Cheese-maggot, *Piophila casei* (Pi-oph'i-la ca'se-i) is the larva of a small black fly, less than half the size of the House-fly. It belongs to the small subfamily *Piophilinæ* (Pi-oph-i-li'næ), in which vein II of the wings is quite closely united with vein III. This fly lays its eggs on cheese, ham, and bacon; the larvæ live in these substances and are often serious pests. They are commonly known as "skippers" on

account of the remarkable jumps which they can make. This is accomplished by first bringing the head and tail ends together and then suddenly straightening the body. In this way one of these maggots can jump several inches.

To the genus *Ephydra* (Eph'y-dra) of the subfamily *Ephydrinæ* (Eph-y-dri'næ) belong several species the larvæ of which live in marine or strongly alkaline waters. In the far West and in Mexico these larvæ occur in the alkaline lakes in countless numbers; and are washed ashore in such quantities that bushels of them can be collected. They are gathered by the Indians, who dry them and use them for food, which they call Koo-cha'bee.

The Pomace-flies.—These are certain small yellowish flies from one-eighth to one-sixth of an inch in length, which are very common about the refuse of cider-mills, decaying fruit, and fermenting vats of grape pomace. These are the pomace-flies; and their larvæ live in the decaying fruit. A very common species is the Vine-loving Pomace-fly, *Drosophila ampelophila* (Dro-soph'i-la am-pe-loph'i-la) (Fig. 594).

FIG. 594.—*Drosophila ampelophila.*

Family HIPPOBOSCIDÆ (Hip-po-bos'ci-dæ).

The Louse-flies.

The louse-flies are very abnormal flies that, in the adult state, live like lice, parasitically, upon the bodies of birds and mammals. Some species are winged, others are wingless, and still others are winged for a time and then lose their wings.

The body is depressed; the head is closely attached to the thorax, which is notched to receive it. The antennæ are apparently one-jointed, with a terminal bristle or style; they are situated in a depression near the mouth. The

frontal suture is present. The legs are broadly separated by the sternum; they are comparatively short and stout; the tarsal claws are strong and are often furnished with teeth. The winged forms vary greatly in the venation of the wings. The veins near the costal border are usually strong while the others are weak. Figure 595 represents

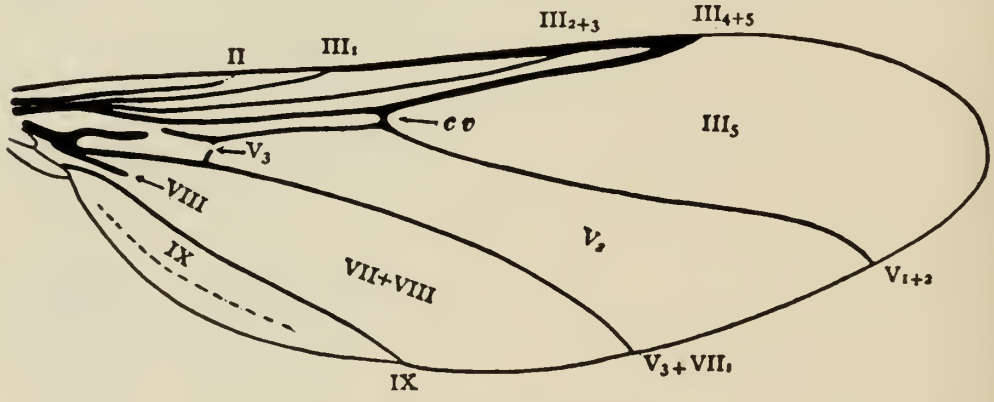

FIG. 595.—Wing of *Olfersia*.

the venation of *Olfersia*. In this genus veins III_2+_3 and III_4+_5 separate near the base of the wing. In *Hippobosca* they separate at or beyond the middle of the wing.

Even more remarkable than the parasitic life of the adult flies is the mode of reproduction of these insects. The egg is hatched within the body of the parent, the larva is nourished in this position till it is full-grown, and is not born till it is ready to change to a pupa. This mode of reproduction is also characteristic of the two following families, which are frequently on this account classed with this one as a division of the Diptera, termed *Pupipara* (Pu-pip'a-ra).

The most common member of the Hippoboscidæ is the Sheeptick, *Melophagus ovinus* (Me-loph'a-gus o-vi'nus). This is a wingless species (Fig. 596), which lives upon sheep. *Hippobosca equina* (Hip-po-bos'ca e-qui'na) is winged and lives on the horse. *Olfersia americana* (Ol-fer'si-a a-mer-i-ca'na) is also winged and is common on owls and other birds. The species of the genus *Lipoptera* (Li-pop'te-ra) are winged at first and live on birds; later they migrate to quadrupeds,

FIG. 596.

where they remain, and having no further use for their wings, they lose them.

Family NYCTERIBIIDÆ (Nyc-ter-i-bi'i-dæ).

The Bat-ticks.

The bat-ticks are wingless parasites of bats. The body is depressed; the head is small and folded back into a groove on the dorsum of the thorax. The compound eyes are wanting; the ocelli are present or wanting. The legs are long, and the tarsal claws of ordinary form. Although wingless the halteres are present.

The mode of reproduction is similar to that of the Hippoboscidæ.

Family BRAULIDÆ (Brau'li-dæ).

The Bee-louse.

This is a minute insect, one-sixteenth of an inch in length, which is parasitic upon the Honey-bee (Fig. 597). It is found clinging to the thorax of queens and drones. It is wingless, and also lacks halteres. The head is large, but lacks both compound eyes and ocelli. The legs are comparatively short; the last segment of the tarsus is furnished with a pair of comb-like appendages. Only a single species is known; this is *Braula cæca* (Brau'la cæ'ca). Its mode of reproduction is similar to that of the Hippoboscidæ.

FIG. 597.

CHAPTER XX.

Order SIPHONAPTERA (Siph-o-nap'te-ra).

The Fleas.

The members of this order are practically wingless, the wings being represented only by minute scaly plates. The mouth-parts are formed for sucking. The metamorphosis is complete.

These tiny tormentors are best known to us in the adult state; for it is only during this period that they annoy us and our household pets. The larvæ and pupæ are rarely observed except by students who search for them.

The name of the order is from two Greek words: *siphon*, a tube; and *apteros*, wingless. It refers to the form of the mouth and to the wingless condition of the insects.

In our more common fleas the body of the adult is oval and greatly compressed, which allows the insect to glide through the narrow spaces between the hairs of its host. The integument is smooth, quite hard, and naked, except that there are many strong spines, which are arranged with great regularity (Fig. 598), and thus afford good characters for distinguishing the different species. The smoothness and firmness of the body makes it easy for the insect to escape when caught between the fingers of man or the teeth of lower animals. Doubtless the backward projecting

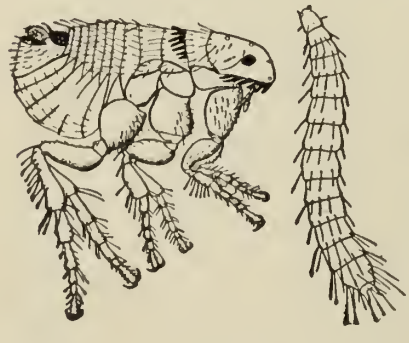

FIG. 598.—The Dog-flea and its larva.

spines also aid them in their efforts to escape, as every wriggle of the body pushes it forward. When once out of the clutch of an enemy, they quickly leap away.

The head is broadly joined to the thorax. There are no compound eyes; but on each side of the head there is a large ocellus, and hidden in a groove behind the ocellus is the antenna. The mouth-parts are formed for piercing and sucking; the sucking-tube is formed of the upper lip and the two mandibles; the maxillæ are small, triangular plates and bear long, four-jointed palpi; the labium is minute and bears a pair of terminal, three-jointed palpi. The mesothorax and metathorax each bears a pair of flat scales, which are supposed to be rudimentary wings. The legs are long and strong, and fitted for leaping; the hinder pair are the largest and the middle pair next in size.

The eggs are scattered about the floors of dwellings and in the sleeping-places of infested animals. The larvæ are slender, worm-like creatures, with a distinct head and without legs (Fig. 598). They have biting mouth-parts, and feed upon the decaying particles of animal and vegetable matter always to be found in the dirt in which they live. When full-grown the larva spins a cocoon within which the pupa state is passed.

Of the domestic animals only the dog, cat, rabbit, pigeons, and poultry have fleas. They are most common on dogs and pigeons. But the species of fleas do not appear to be so strictly limited to particular animals as are the lice and some other parasites; for the species that commonly infests dogs and cats will also attack man without hesitation, and in this country seems to be more troublesome to our race than the Human-flea.

To rid a dog or cat of fleas it should be dusted with Persian insect powder (*Pyrethrum*), and its sleeping-place thoroughly cleaned. The bedding in kennels should be of some substance which can be replaced frequently, as shavings or straw, and when replaced the old bedding should be

burned, and the floors wet with kerosene emulsion or some other insecticide that will destroy the eggs and larvæ.

In regions where fleas abound much relief can be obtained by the use of rugs on the floors of dwellings instead of carpets. The frequent shaking of the rugs and cleaning of the floors will prevent the breeding of these pests within the house. As a single flea will inflict many bites, it often happens that a house will seem to be overrun by them when only a few are present. In such cases a careful search for and capture of the offenders will soon remedy the evil. We have found that in catching fleas greater success attends our efforts if the thumb and forefinger be wet before seizing the flea, and the insect be placed in a dish of water before we attempt to destroy it. Otherwise the insect is apt to escape while we are trying to destroy it.

People that suffer from the attacks of these pests can also gain much relief by dusting the upper part of their stockings each morning with Persian insect powder, and by sprinkling a small quantity of this powder between the sheets of their beds at night.

This order contains only a single family, the *Pulicidæ* (Pu-lic'i-dæ), of which five or six genera and about twenty-five species are now known. The species that are most frequently observed are the following :—

The Dog-flea, *Ceratopsyllus serraticeps* (Cer-a-to-psyl'lus ser-rat'i-ceps).—This is the most common flea that infests dog, cat, and man in this country (Fig. 598). It is reddish brown ; the lower margin of the head and the hinder margin of the prothorax each bear on each side from seven to nine black, tooth-like spines.

The Human-flea, *Pulex irritans* (Pu'lex ir-ri'tans). This species lacks the comb-like rows of black spines on the lower side of the head and on the hinder margin of the prothorax. It is also usually darker than the preceding species, being sometimes pitchy brown. It is a common pest in dwellings in Europe, but is comparatively rare in this country.

The Chigoe (Chig'ō) or Jigger, *Sarcopsylla penetrans* (Sar-co-psyl'la pen'e-trans), is a small flea found in the West Indies and South America, which often causes serious trouble to men by burrowing beneath the skin of the foot. It is the fertile female that does this, and soon after entering its host the body of the flea becomes distended with eggs and acquires the size of a pea.

In the southern United States the names Chigoe and Jigger are improperly applied to the harvest-mites, which are the immature six-legged forms of various mites that attach themselves like ticks to the skin and become gorged with blood.

CHAPTER XXI.

Order COLEOPTERA (Co-le-op'te-ra).

The Beetles.

The members of this order have a pair of horny wing-covers, called elytra, which meet in a straight line down the back, and beneath which there is a single pair of membranous wings. The mouth-parts are formed for biting. The metamorphosis is complete.

Beetles can be readily distinguished from all other insects except earwigs by the possession of horny, veinless wing-covers which meet in a straight line down the back (Fig. 599); and they differ from earwigs in lacking the pincer-like appendages at the tail end of the body characteristic of those insects (see page 103). Beetles also differ from earwigs in having a complete metamorphosis.

FIG. 599.

The name of the order, Coleoptera, is from two Greek words: *coleos*, a sheath; and *pteron*, a wing. It refers to the sheath-like structure of the elytra (el'y-tra) or wing-covers, which were formerly believed to be modified wings.

These wing-covers apparently occupy the position of the fore wings, and can be moved somewhat as wings are moved. Their structure, however, resembles that of the body-wall rather than that of wings; and in some beetles (e.g., *Dytiscus*) rudiments of the fore wings exist beneath the elytra.

The homology of the elytra is most easily understood by a study of the corresponding parts in other orders of insects. In the lower orders of insects there exists at the base of each wing a small sclerite; these have been termed the *paraptera* (pa-rap'te-ra), from the Greek *para*, beside, and *pteron*, a wing. In some of the orders of insects the paraptera of the mesothorax are in the form of a cup-like scale over the base of each fore wing, and are termed the *tegulæ*; this form is well shown by most Hymenoptera. In the Lepidoptera they are even more prominent, and in many cases extend back a considerable distance on each side; those of this order have been named the *patagia*. In the Coleoptera the paraptera of the mesothorax reach their greatest development, and so strongly resemble wings that they are still commonly believed to be the fore wings.

The hind wings are membranous, and in most species very efficient organs of flight. But in some of the pre-eminently running beetles the hind wings are wanting, and the elytra serve only as a protection to the abdomen. With some of these insects the elytra are even grown together where they meet on the middle line of the back. Instances of this kind are not uncommon among the ground-beetles and the darkling beetles.

The different mouth-parts are very evenly developed; we do not find some of them greatly enlarged at the expense of others, as in several other orders of insects. The upper lip, or labrum, is usually distinct; the mandibles are powerful jaws fitted either for seizing prey or for gnawing; the maxillæ are also well developed and are quite complicated, consisting of several distinct pieces; the maxillary palpi are usually prominent; and the lower lip, or labium, is also well developed and complicated, consisting of several parts and bearing prominent labial palpi.

The larvæ are commonly called grubs. They are usually furnished with six thoracic legs, and often with a single proleg at the caudal end of the body; some, however, as

the larvæ of the snout-beetles, are entirely destitute of jointed legs. The pupæ have the partially developed elytra, wings, and legs folded upon the breast, but in distinct sheaths (Fig. 600). These insects usually transform in rude cocoons made of earth or of bits of wood fastened together by a viscid substance excreted by the larvæ. Many wood-burrowing species transform in the tunnels made by the larvæ; and some of the Dermestids as well as some of the lady-bugs transform in the last larval skin.

FIG. 600.

Both beetles and their larvæ vary greatly in their habits; while some species are very beneficial to man, others are extremely noxious.

More than eleven thousand species of beetles, representing upwards of eighty families, are known to occur in America north of Mexico. The following synopsis will aid the student in learning the relationships of these families:—

SYNOPSIS OF THE COLEOPTERA.

(*See page* 505 *for a table for determining specimens.*)

A. THE TYPICAL COLEOPTERA.—Beetles with the head and mouth-parts of the ordinary form.

B. THE ISOMERA (I-som'e-ra).—Typical Coleoptera in which the hind tarsi have as many segments as the others. (There are a few exceptions to this character among the Clavicornia.)

C. Isomera in which the fourth and fifth tarsal segments are not grown together.

D. THE ADEPHAGA (A-deph'a-ga) or *Predaceous Beetles.* — Isomera in which the first three ventral abdominal segments are grown together, and the first of these is divided by the hind coxal cavities so that the sides are separated from the very small medial part.

The Tiger-beetles. p. 516.....Family CICINDELIDÆ.
The Ground-beetles. p. 518.....Family CARABIDÆ.
The Amphizoids. p. 521.....Family AMPHIZOIDÆ.
The Haliplids. p. 522.....Family HALIPLIDÆ.
The Predaceous Diving-beetles. p. 523.Family DYTISCIDÆ.
The Whirligig Beetles. p. 525.....Family GYRINIDÆ.

DD. THE CLAVICORNIA (Clav-i-cor'ni-a) or Clavicorn Beetles. —Isomera in which the first ventral abdominal segment is visible for its entire breadth, and in which the antennæ are usually clavate or capitate, but not lamellate.

The Water Scavenger Beetles. p. 527. Family HYDROPHILIDÆ.
The Beaver-parasite. p. 529. ....Family PLATYPSYLLIDÆ.
The Leptinids. p. 529..... ....Family LEPTINIDÆ.
The Carrion-beetles. p. 529.....Family SILPHIDÆ.
The Scydmænids. p. 531.....Family SCYDMÆNIDÆ.
The Pselaphids. p. 531.....Family PSELAPHIDÆ.
The Rove-beetles. p. 532.....Family STAPHYLINIDÆ.
The Feather-wing Beetles. p. 533. Family TRICHOPTERYGIDÆ.
The Hydroscaphids. p. 533. ...Family HYDROSCAPHIDÆ.
The Sphæriids. p. 533.....Family SPHÆRIIDÆ.
The Scaphidiids. p. 533.....Family SCAPHIDIIDÆ.
The Phalacrids. p. 534.... .....Family PHALACRIDÆ.
The Corylophids. p. 534..... .Family CORYLOPHIDÆ.
The Lady-bugs. p. 534.....Family COCCINELLIDÆ.
The Endomychids. p. 535.....Family ENDOMYCHIDÆ.
The Erotylids. p. 536..... ..Family EROTYLIDÆ.
The Colydiids. p. 537.....Family COLYDIIDÆ.
The Rhyssodids. p. 537.....Family RHYSSODIDÆ.
The Cucujids. p. 537.....Family CUCUJIDÆ.
The Cryptophagids. p. 538.....Family CRYPTOPHAGIDÆ.
The Mycetophagids. p. 538.....Family MYCETOPHAGIDÆ.
The Dermestids. p. 538.....Family DERMESTIDÆ.
The Histerids. p. 541.....Family HISTERIDÆ.
The Nitidulids. p. 541..... Family NITIDULIDÆ.
The Trogositids. p. 542.....Family TROGOSITIDÆ.
The Monotomids. p. 542.....Family MONOTOMIDÆ.
The Lathridiids. p. 542.....Family LATHRIDIIDÆ.
The Derodontids. p. 542.....Family DERODONTIDÆ.
The Pill-beetles. p. 542.....Family BYRRHIDÆ.
The Georyssids. p. 543.....Family GEORYSSIDÆ.
The Parnids. p. 543.....Family PARNIDÆ.
The Heterocerids. p. 543 .....Family HETEROCERIDÆ.

DDD. THE SERRICORNIA (Ser-ri-cor'ni-a) or Serricorn Beetles. —Isomera in which the first ventral abdominal segment is visible for its entire breadth, and in which the antennæ are usually serrate.

The Dascyllids. p. 544.....Family DASCYLLIDÆ.
The Rhipicerids. p. 544.....Family RHIPICERIDÆ.
The Click-beetles. p. 544.....Family ELATERIDÆ.
The Throscids. p. 548.....Family THROSCIDÆ.
The Buprestids. p. 548.....Family BUPRESTIDÆ.
The Fire-fly Family. p. 550.....Family LAMPYRIDÆ.
The Malachiids. p. 552.....Family MALACHIIDÆ.
The Checkered-beetles. p. 552.....Family CLERIDÆ.
The Ptinids. p. 553.....Family PTINIDÆ.
The Cupesids. p. 553.....Family CUPESIDÆ.
The Ship-timber Beetle Family. p. 553.
Family LYMEXYLIDÆ.
The Ciids. p. 554.....Family CIIDÆ.
The Sphindids. p. 554.....Family SPHINDIDÆ.

DDDD. THE LAMELLICORNIA (La-mel-li-cor'ni-a) or Lamellicorn Beetles.—Isomera in which the first ventral abdominal segment is visible for its entire breadth and in which the antennæ have a lamellate club.

The Stag-beetles. p. 554.....Family LUCANIDÆ.
The Scarabæids. p. 556.....Family SCARABÆIDÆ.

CC. THE PHYTOPHAGA (Phy-toph'a-ga).—Isomera in which the fourth and fifth tarsal segments are grown together; the fourth tarsal segment is usually very small, and concealed in a notch in the third segment.

The Aberrant Long-horned Beetles. p. 566.
Family SPONDYLIDÆ.
The Long-horned Beetles. p. 567.....Family CERAMBYCIDÆ.
The Leaf-beetles. p. 574.....Family CHRYSOMELIDÆ.
The Pea-weevil Family. p. 581.....Family BRUCHIDÆ.

BB. THE HETEROMERA (Het-e-rom'e-ra) or Heteromerous Beetles.—Typical Coleoptera in which the fore and middle tarsi are five-jointed, and the hind tarsi four-jointed.

The Darkling Beetles. p. 582.....Family TENEBRIONIDÆ.
The Ægialitids. p. 584.....Family ÆGIALITIDÆ.
The Cistelids. p. 584.....Family CISTELIDÆ.
The Othniids. p. 584.....Family OTHNIIDÆ.
The Lagriids. p. 584.....Family LAGRIIDÆ.
The Monommids. p. 584.....Family MONOMMIDÆ.
The Melandryids. p. 585.....Family MELANDRYIDÆ.
The Pythids. p. 585.....Family PYTHIDÆ.
The Œdemerids. p. 585.....Family ŒDEMERIDÆ.
The Cephaloids. p. 585.....Family CEPHALOIDÆ.

The Mordellids. p. 586.....Family MORDELLIDÆ.
The Anthicids. p. 586.....Family ANTHICIDÆ.
The Pyrochroids. p. 586.....Family PYROCHROIDÆ.
The Blister-beetles. p. 586.....Family MELOIDÆ.
The Rhipiphorids. p. 589.....Family RHIPIPHORIDÆ.
The Stylopids. p. 589.....Family STYLOPIDÆ.

AA. THE RHYNCHOPHORA (Rhyn-choph'o-ra) or Snout-Beetles.—Beetles in which the head is more or less prolonged into a beak, and in which the palpi are short and rigid.

The Rhinomacerids. p. 590.....Family RHINOMACERIDÆ.
The Rhynchitids. p. 591.....Family RHYNCHITIDÆ.
The Leaf-rolling Weevils. p. 591.....Family ATTELABIDÆ.
The Byrsopids. p. 591.....Family BYRSOPIDÆ.
The Scarred Snout-beetles. p. 592.....Family OTIORHYNCHIDÆ.
The Curculios. p. 593.....Family CURCULIONIDÆ.
The Brenthids. p. 594.....Family BRENTHIDÆ.
The Bill-bugs. p. 595.....Family CALANDRIDÆ.
The Engraver-beetles. p. 596.....Family SCOLYTIDÆ.
The Anthribids. p. 598.....Family ANTHRIBIDÆ.

CLASSIFICATION OF THE COLEOPTERA.

(*For Advanced Students.*)

In order to use the table for determining the families of beetles it is necessary that the student should become familiar with certain

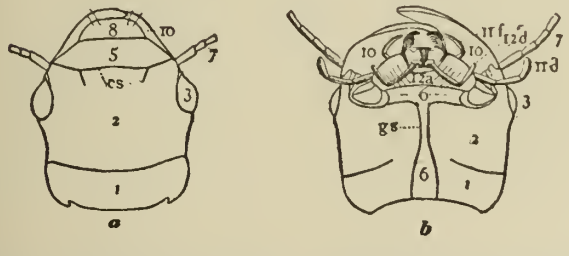

FIG. 601.—Head of *Harpalus*: *a*, dorsal aspect; *b*, ventral aspect; 1, occiput; 2 epicranium; 3, eye; 5, clypeus; 6, gula; 7, antenna; 8, labrum; 10, mandibles; 11*d*, maxillary palpus; 11*f*, galea or outer lobe of maxilla; 12*a*, submentum; 12*d*, labial palpus; *cs*, clypeal suture; *gs*, gular suture.

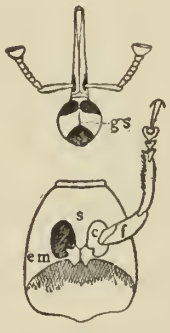

FIG. 602.—Head and prothorax of *Rhynchophorus*: *c*, coxa; *em*, epimeron; *f*, femur; *gs*, gular suture; *s*, prosternum

terms not defined in the discussion of the external anatomy of insects on pages 56-67. The following notes are therefore given as a supplement to that discussion.

The Head.—Two of the sclerites that enter into the composition

of the external wall of the head are frequently referred to in descriptions of beetles; these are the clypeus and the gula. The *clypeus* (clyp'e-us) is situated on the dorsal side of the head, and is the sclerite to which the labrum is attached. (Fig. 601, *a*, 5.) The *gula* (gu'la) is the central portion of the ventral wall of the head, and is the part which bears the labium (Fig. 601, *b*, 6). The sutures which bound the gula, one on each side, are termed the *gular sutures* (Fig. 601, *b*, *gs*). In the Rhynchophora the gula appears to be wanting, and there is a single suture on the middle line of the head (Fig. 602, *gs*); in this case the gular sutures are said to be confluent. The suture which separates the clypeus from the sclerite immediately behind it (the epicranium) is termed the *clypeal suture* (Fig. 601, *a*, *cs*).

The Antennæ.—The more common types of antennæ are named and figured on page 60. But it is necessary to define two other terms here. In many insects the first segment of the antenna is long and the antenna is bent suddenly at the joint between the first and second segments; such antennæ are said to be elbowed or *geniculate* (ge-nic'u-late). In some pectinate antennæ the tooth-like processes are very long, giving the antenna a more or less fan-like appearance; such antennæ are defined as *flabellate* (fla-bel'late) (Fig. 603).

FIG. 603.

The Mouth-parts.—The labrum and mandibles are sufficiently described on page 61. The parts of the maxillæ are represented in Figs. 604, 605, and 606; of these there are five primary

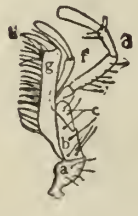

FIG. 604.—Maxilla of *Cicindela.*

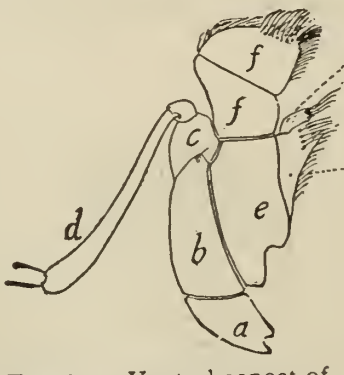

FIG. 605.—Ventral aspect of maxilla of *Hydrophilus*

FIG. 606.—Dorsal aspect of maxilla of *Hydrophilus.*

parts and three appendages. The primary parts are the *cardo* or hinge (*a*), the *stipes* (sti'pes) or footstalk (*b*), the *palpifer* (pal'pi-fer) or palpus-bearer (*c*), the *subgalea* (sub-ga'le-a) or helmet-bearer (*e*), and the *lacinia* (la-cin'i-a) or blade (*g*). The appendages are the *maxillary palpus* or feeler (*d*), the *galea* (ga'le-a) or outer lobe or superior lobe (*f*, *f*), and the *digitus* (dig'i-tus) or finger (*h*).

The parts of the maxilla to which reference is most often made are the palpus and the galea. The number and form of the segments of the palpus are much used in descriptions; as is also the presence or absence of the galea. When the galea is developed as a distinct appendage, the maxilla is said to be bilobed, the galea being termed the *outer lobe*, and the lacinia, or blade, the *inner lobe* (Fig. 604). When the galea is not developed so as to appear as an appendage the maxilla is said to have but one lobe.

Much use is made of the form of the parts of the *labium* or lower lip in descriptions of beetles. When fully developed the labium consists of three principal parts and a pair of appendages. The principal parts are the *submentum*, the *mentum*, and the *ligula*; the appendages are the *labial palpi*. The basal part of the labium, the part which is joined to the gula, is the *submentum* (Fig. 607, *sm*). By an unfortunate error this sclerite is almost invariably described in works on the Coleoptera as the *mentum*. This fact should be borne in mind by the student when using any of the older books on this subject. The intermediate portion of the labium is the *mentum* (Fig. 607, *m*); and the distal portion the *ligula*. The ligula is a compound organ; but in beetles the sutures between the different sclerites of which it is composed are usually obsolete. Three parts, however, are commonly distinguished, a central part, which is sometimes divided at the tip, the *glossa* (Fig. 607, *g*), and two parts, one on each side of the glossa, the *paraglossæ* (Fig. 607, *p*). The part on each side which bear the palpus is termed, when it is distinct, the *palpiger*.

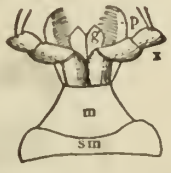

FIG. 607. — Labium of *Creophilus*: *sm*, submentum; *m*, mentum; *x*, labial palpus; *g*, glossa, *p*, paraglossa.

The Thorax.—Each segment of the thorax is composed of several sclerities. The shape and relative position of these sclerites afford characters which are much used in classification. Figure 608 is a diagrammatic representation of what is considered the typical arrangement of these parts in each of the thoracic segments. Each segment of the thorax is a ring, which is divided into four parts: a dorsal, a ventral, and two lateral. The dorsal part is named the *notum* (no'tum) or *tergum* (ter'gum); each lateral part the *pleurum* (pleu'rum); and the ventral part the *sternum* (ster'num).

When the notum or sternum of a particular thoracic segment is to be indicated, it is done by the use of one of the prefixes *pro*, *meso*, or *meta*. In this way are formed the terms *pronotum*, *mesonotum*, *metanotum*, *prosternum*, *mesosternum* and *metasternum;* which are applied to the nota and sterna of the prothorax, mesothorax, and metathorax respectively.

The tergum or dorsal wall of each thoracic segment is composed typhically of four sclerities. These are arranged in a linear series (Figs. 608, 609). They are named, beginning with the first or most cephalic, *præscutum* (prae-scu'tum) (*a*), *scutum* (scu'tum) (*b*), *scutellum* (scu-tel'lum) (*c*), and *postscutellum* (post-scu-tel'lum) (*d*). In the prothorax of beetles the sutures between these four sclerites are obsolete, the pronotum appearing to be composed of a single sclerite (Fig. 609, 14). The mesonotum and metanotum are usually covered by the wings and

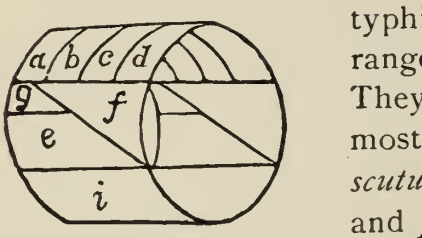

FIG. 608.—Diagram of the fixed parts of a thoracic segment.

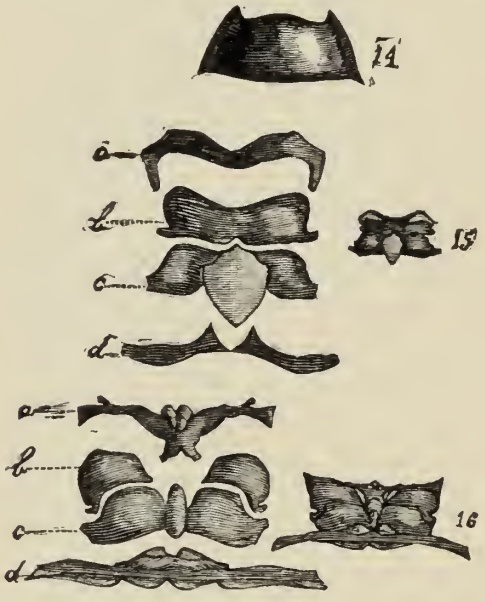

FIG. 609.—Dorsal aspect of the thorax of a beetle; 14, pronotum; 15, mesonotum; 16, metanotum. *Dysticus*, dissected. (After Audouin.)

FIG. 610.—Figure of a beetle, showing the scutellum.

elytra, excepting the scutellum of the mesothorax, which is usually quite conspicuous, appearing as a more or less triangular piece between the elytra at their base (Fig. 610). As this is the only one of the three scutella that is usually seen, it is termed *the* scutellum.

Each pleurum or lateral part of each thoracic segment is composed chiefly or entirely of two sclerites, arranged more or less obliquely. The first of these (Fig. 608, *e*) is the *episternum* (ep-i-ster'num), the second (Fig. 608, *f*) is the *epimeron* (ep-i-me'ron). A third sclerite (Fig. 608, *g*) is sometimes present near the dorsal end of the episternum; this is the *parapteron* (pa-rap'te-ron.) Paraptera have not been found in the prothorax. In beetles the paraptera of the mesothorax

are greatly developed; they project from the body wall, with which they are hinged, and constitute the wing-covers or elytra. The paraptera of the metathorax are concealed.

Each sternum or ventral part of each thoracic segment is composed

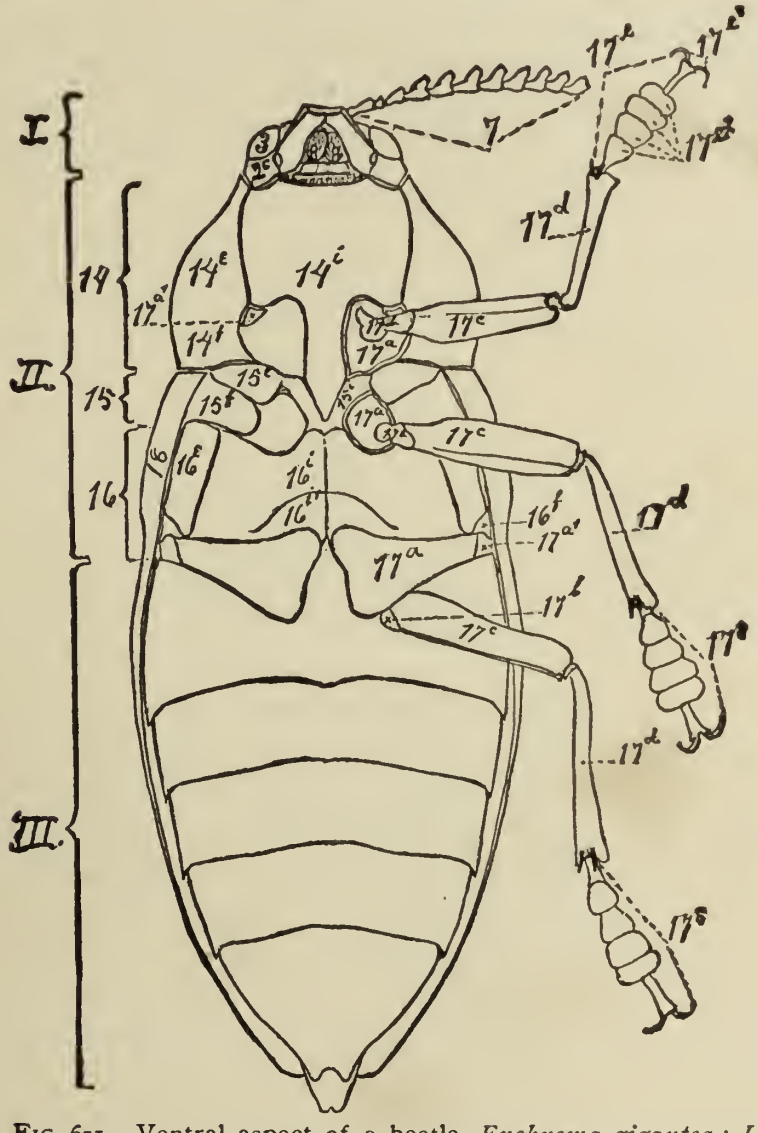

FIG. 611.—Ventral aspect of a beetle, *Enchroma gigantea*: *I*, head; 2^c, gena of the epicranium; 3, eye; 7, antenna; *II*, thorax; 14, prothorax; 14^e, proepisternum or episternum of the prothorax; 14^f, proepimeron or epimeron of the prothorax; 14^i, prosternum; 15, mesothorax; 15^e, mesoepisternum; 15^f, mesoepimeron; 15^i, mesosternum; 16, metathorax; 16^e, metaepisternum; 16^f, metaepimeron; 16^i, metasternum; 16^{i1}, antecoxal piece of the metasternum; 17^a, coxa; 17^{a1}, trochantin; 17^b, trochanter; 17^c, femur; 17^d, tibia; 17^e, tarsus; 17^{e1}, tarsal claws; 17^{e2}, pulvilli; 18, elytron.

of a single sclerite (Fig. 608. *i*.) As indicated above, the three sterna are designed as the prosternum, mesosternum, and metasternum, respectively.

In some beetles the metasternum is divided into two unequal por-

tions by a suture which extends transversely a short distance in front of the caudal margin; the smaller sclerite which borders the posterior coxæ in front and often passes between them is called the *ante-coxal piece of the metasternum* (Fig. 611, 16 i^1).

The openings in the thoracic segments in which the legs are inserted are termed the *coxal cavities*. Much use is made in the classification of beetles of the form of the coxal cavities of the prothorax. When the epimera of the prothorax extend behind the coxæ and reach the prosternum, the coxal cavities are said to be *closed* (Fig. 612);

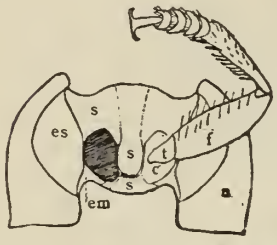

FIG 612.—Prothorax of *Harpalus*; *c*, coxa; *em*, epimeron; *es*, episternum; *f*, femur; *n*, pronotum; *s*, *s*, *s*, prosternum.

FIG. 613.—Prothorax of *Penthe*; *c*, coxa; *cc*, coxal cavity; *f*, femur; *s*, prosternum; *t*, trochanter.

FIG 614.

when the epimera do not extend behind the coxæ to the prosternum, the coxal cavities are described as *open* (Fig. 613).

The Legs.—The parts of the leg are described on page 62. In addition to what is said there it should be noted that in beetles the coxæ of the hind legs are frequently broad plates which appear to belong to the fixed parts of the thorax, differing greatly in form from the fore and middle coxæ (Fig. 611, 17^a).

In many beetles there is a small sclerite which is supposed to be an appendage of the coxa; this is the *trochantin* (tro-chan'tin); the trochantins of the fore and hind coxæ are represented in Fig. 611, and are lettered 17^{a1}.

The student should understand clearly the numbering of the segments of the tarsi. In counting these segments the claws borne by the last segment are not included, but the segment that bears these claws is counted. This fact should be carefully noted. We have found that students are very apt to omit counting this segment, especially when it differs in form from the preceding segments. Two of the more common types of the tarsi of beetles are represented in Fig. 614, with the segments numbered.

Students wishing to carry their study of beetles beyond the scope of this text-book should procure the "Classification of the Coleoptera of

North America," by LeConte and Horn. This work can be purchased of the Secretary of the American Entomological Society, Philadelphia, Pa. In the following pages we have followed closely the classification proposed by these authors, and have made free use of the characterizations given by them; hence it will be easy for a student to pass from a study of this chapter to the use of that indispensable work.

TABLE FOR DETERMINING THE FAMILIES OF THE COLEOPTERA.*

A. Head not prolonged into a narrow beak; palpi always flexible; two gular sutures at least before and behind (Fig. 601); prosternal sutures distinct (Fig. 612); the epimera of the prothorax not meeting on the middle line behind the prosternum (Fig. 612).

TYPICAL COLEOPTERA.

B. Hind tarsi with at least as many segments as the others.

C. Tarsi usually apparently four-jointed, the fourth segment being reduced in size so as to form an indistinct segment at the base of the last segment, with which it is immovably united (Fig. 615, 4); the first three segments of the tarsi dilated and

FIG. 615.

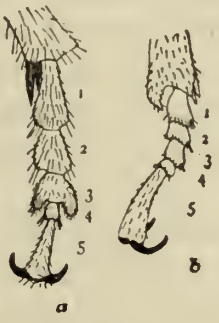

FIG. 616.

FIG. 617.

brush-like beneath; the third segment bilobed. In a single family, the Spondylidæ, the fourth segment of the tarsus, although much reduced and immovably united with the fifth, is distinctly visible, the first three segments are but slightly dilated, and the third is either bilobed or not (Fig. 616, *a* and *b*)..... .....PHYTOPHAGA.

D. Fourth segment of tarsus distinctly visible; segments of antennæ with deep impressions containing the organs of special sense (Fig. 617). p. 566.... .. ..SPONDYLIDÆ.

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* This table is based largely on the tables given by Le Conte and Horn. Aid was also derived in its preparation from the table of European Coleoptera by L. Redtenbacher.

DD. Fourth segment of tarsus inconspicuous; organs of special sense of antennæ diffused. This group contains three families, which are so connected by intermediate forms that it is not easy to separate them. The following characters will aid the student in separating the more typical forms:

E. Body elongate; antennæ almost always long, often as long as the body or longer. The larvæ are borers. p. 567. CERAMBYCIDÆ.

EE. Body short and more or less oval; antennæ short.

F. Front prolonged into a broad quadrate beak; elytra rather short, so that the tip of the abdomen is always exposed. The larvæ live in seeds. p. 581. BRUCHIDÆ.

FF. Front not prolonged into a beak; usually the tip of the abdomen is covered by the elytra. Both larvæ and adults feed on the leaves of plants. p. 574. CHRYSOMELIDÆ.

CC. Tarsi varying in form, but when five-jointed not of the type described under C, the joint between the fourth and fifth segments being flexible.

D. Ventral part of the first segment of the abdomen divided by the hind coxal cavities, so that the sides are separated from the very small medial part.

E. Metasternum with an antecoxal piece, separated by a well-marked suture reaching from one side to the other, and extending in a triangular process between the hind coxæ.

F. Antennæ eleven-jointed; hind coxæ mobile, and of the usual form; habits terrestrial.

G. Antennæ inserted on the front above the base of the mandibles. p. 516. CICINDELIDÆ.

GG. Antennæ arising at the side of the head between the base of the mandibles and the eyes. p. 518. CARABIDÆ.

FF. Antennæ ten-jointed; hind coxæ fixed and greatly expanded so as to conceal the basal half of the hind femora and from three to six of the abdominal segments; habits aquatic. p. 522. HALIPLIDÆ.

EE. Metasternum either with a very short antecoxal piece, which is separated by an indistinct suture, and which is not prolonged posteriorly between the coxæ, or without an antecoxal piece.

F. Metasternum with a very short antecoxal piece. p. 521. AMPHIZOIDÆ.

FF. Metasternum without an antecoxal piece.

G. Legs fitted for swimming.

H. With only two eyes. p. 523.....DYTISCIDÆ.

HH. With four eyes, two above and two below. p. 525.....GYRINIDÆ.

GG. Legs fitted for walking. p. 537.....RHYSSODIDÆ.

DD. Ventral part of the first segment of the abdomen visible for its entire breadth.

E. Antennæ with a lamellate club (Fig. 74, 8, page 60).

F. Plates composing club of antennæ not capable of close apposition, and usually not flattened. p. 554. LUCANIDÆ.

FF. Plates composing club of antennæ capable of close apposition, and flattened. p. 556.....SCARABÆIDÆ.

EE. Antennæ either clubbed or not, but when clubbed not lamellate.

F. Elytra short, leaving the greater part of the abdomen exposed; the suture between the elytra when closed straight; wings present, and when not in use folded beneath the short elytra; the dorsal part of the abdominal segments entirely horny.

G. Abdomen flexible, and with seven or eight segments visible below. p. 532.....STAPHYLINIDÆ.

GG. Abdomen not flexible, and with only five or six ventral segments visible. p. 531.....PSELAPHIDÆ.

FF. Elytra usually long, covering the greater part of the abdomen; when short the wings are wanting, or if present are not folded under the short elytra when at rest; the dorsal part of the abdominal segments partly membranous.

G. Hind tarsi five-jointed.

H. Antennæ elbowed, and clavate.

I. Elytra truncate behind, leaving two segments of the abdomen uncovered. p. 541 ....HISTERIDÆ.

II. Elytra entire. p. 553 .....PTINIDÆ.

HH. Antennæ rarely elbowed, and then not clavate.

I. Maxillary palpi as long as or longer than the antennæ. p. 527.....HYDROPHILIDÆ.

II. Maxillary palpi much shorter than the antennæ.

J. Tarsal claws very large; the first three abdominal segments grown together on the ventral side. p. 543..... ...PARNIDÆ.

JJ. Tarsal claws of usual size; ventral abdominal segments usually free; sometimes (Buprestidæ) the first two are grown together.

K. Abdomen with only five ventral segments.

L. Femur joined to the apex or very near the apex of the trochanter. p. 553...PTINIDÆ.

LL. Femur joined to the side of the trochanter.

M. Anterior coxæ globular or transverse, usually projecting but little from the coxal cavity.

N. Anterior coxæ transverse, more or less cylindrical.

O. Posterior coxæ grooved for the reception of the femora.

P. Legs stout, retractile; tibiæ dilated, usually with a furrow near the outer end for the reception of the tarsi; tibial spurs distinct. p. 542. BYRRHIDÆ.

PP. Tibiæ slender, with small and sometimes obsolete terminal spurs, or without spurs.

Q. Head constricted behind; eyes smooth. p. 553.....CUPESIDÆ.

QQ. Head not constricted behind; eyes granulated. p. 544. DASCYLLIDÆ.

OO. Posterior coxæ flat; not grooved for the reception of the femora.

P. Tarsi more or less dilated, first segment not short. p. 541. NITIDULIDÆ.

PP. Tarsi slender, first segment short. p. 542.....TROGOSITIDÆ.

NN. Anterior coxæ globular.

O. Prosternum with a process which extends backward into a groove in the mesosternum.

P. The first two abdominal segments grown together on the ventral side. p. 548.....BUPRESTIDÆ.

PP. Ventral segments free.

Q. Prothorax loosely joined to the mesothorax; front coxal cavities entirely in the prosternum. p. 544. ELATERIDÆ.

QQ. Prothorax firmly joined to the mesothorax; front coxal cavities closed behind by the mesosternum. p. 548...THROSCIDÆ.

OO. Prosternum without a process received by the mesosternum, although it may be prolonged so as to meet the mesosternum.

P. Posterior coxæ contiguous. p. 534. PHALACRIDÆ.

PP. Posterior coxæ separated.

Q. Body very depressed; middle coxal cavities not closed externally by a meeting of the mesosternum and metasternum. p. 537. CUCUJIDÆ.

QQ. Body more or less convex; middle coxal cavities entirely surrounded by the sterna.

R. Prosternum not prolonged behind. p. 538. MYCETOPHAGIDÆ.

RR. Prosternum prolonged meeting the mesosternum.

S. Anterior coxal cavities open behind. p. 538. CRYPTOPHAGIDÆ,

SS. Anterior coxal cavities closed behind. p. 536. EROTYLIDÆ.

MM. Anterior coxæ conical, and projecting prominently from the coxal cavities.

N. Posterior coxæ dilated into plates partially protecting the femora, at least at their bases.

O. Antennæ serrate or flabellate. p. 544.....RHIPICERIDÆ.

OO. Antennæ with the last three segments forming a large club. p. 538. DERMESTIDÆ.

OOO. Antennæ with the last three segments somewhat larger than the preceding, but not suddenly enlarged. p. 542.....DERODONTIDÆ.

NN. Posterior coxæ not dilated into plates partially protecting the femora.

O. Posterior coxæ flat, not prominent, covered by the femora in repose. p. 552.....CLERIDÆ.

OO. Posterior coxæ oval, not prominent. p. 533 .....SCAPHIDIIDÆ.

OOO. Posterior coxæ conical and prominent.

P. Anterior coxæ with distinct trochantins. p. 552...MALACHIIDÆ.

PP. Anterior coxæ without trochantins. p. 553...LYMEXYLIDÆ.

KK. Abdomen with six or more ventral segments.

L. Anterior coxæ flat. p. 529. PLATYPSYLLIDÆ.

LL. Anterior coxæ either globular or conical.

M. Anterior coxæ globular.

N. Prosternum prolonged behind, forming an acute process moving in the mesosternum. p. 544....ELATERIDÆ.

NN. Prosternum not prolonged behind. p. 529 .....LEPTINIDÆ.

MM. Anterior coxæ conical.

N. Posterior coxæ not prominent, flat, covered by the femora in repose. p. 552.....CLERIDÆ.

NN. Posterior coxæ more or less conical and prominent at least internally, not covered by the femora in repose.

O. Posterior coxæ widely separated.

P. Eyes wanting or inconspicuous. p. 529.....SILPHIDÆ.

PP. With well-developed eyes.

Q. Elytra covering the abdomen. p. 531.....SCYDMÆNIDÆ.

QQ. Elytra not covering the entire abdomen. p. 533. SCAPHIDIIDÆ.

OO. Posterior coxæ approximate.

P. Antennæ gradually thickened, or clavate; posterior tarsi not widened. p. 529.....SILPHIDÆ.

PP. Antennæ setaceous, filiform, serrate, pectinate, or flabellate, rarely with three somewhat larger terminal segments, in which case the tarsi are widened.

Q. Anterior coxæ long, with distinct trochantins.

R. Abdomen with seven or eight ventral segments. p. 550. LAMPYRIDÆ.

RR. Abdomen with only six ventral segments. p. 552. MALACHIIDÆ.

QQ. Anterior coxæ without trochantins. p. 553..LYMEXYLIDÆ.

GG. Hind tarsi either only three-jointed or four-jointed, but apparently three-jointed, the third segment being small and concealed in a notch at the end of the second segment. (See also GGG.)

H. Wings fringed with long hairs.

I. Abdomen with six or seven ventral segments.

J. Tarsi four-jointed, the third segment small and concealed in a notch at the end of the second segment. p. 534... .....CORYLOPHIDÆ.

JJ. Tarsi three jointed.

K. Antennæ slender, verticillate, with long hair, abdomen not prolonged. p. 533. TRICHOPTERYGIDÆ.

KK. Antennæ short, not verticillate, abdomen prolonged. p. 533.....HYDROSCAPHIDÆ.

II. Abdomen with only three ventral segments. p. 533.....SPHÆRIIDÆ.

HH. Wings not fringed with hairs.

I. Tarsi with second segment dilated.

J. Tarsal claws appendiculate or toothed; first ventral abdominal segment with distinct curved coxal lines. p. 534.....COCCINELLIDÆ.

JJ. Tarsal claws simple; first ventral abdominal segment without coxal lines. p. 535. ENDOMYCHIDÆ.

II. Tarsi with second segment not dilated.

J. Elytra entirely covering the abdomen; ventral abdominal segments nearly equal. p. 542. LATHRIDIIDÆ.

JJ. Elytra truncate; the first and fifth ventral abdominal segments longer than the others.

K. Maxilla with galea distinct; anterior coxæ small, rounded. p. 542 .....MONOTOMIDÆ.

KK. Galea wanting, anterior coxæ subtransverse. p. 541.....NITIDULIDÆ.

GGG. All tarsi four-jointed.

H. The first four abdominal segments grown together on the ventral side.

I. Tibiæ dilated, armed with rows of spines, and fitted for digging. p. 543.....HETEROCERIDÆ.

II. Tibiæ not dilated nor fitted for digging. p. 537. COLYDIIDÆ.

HH. Ventral segments of abdomen not grown together.

I. Wings fringed with hairs.

J. Hind coxæ contiguous and with plates covering the femora entirely or in part. p. 529. SILPHIDÆ.

JJ. Hind coxæ separate and not covering the femora. p. 543.....CORYLOPHIDÆ.

II. Wings not fringed with hairs.

J. Anterior coxæ transverse. p. 541. NITIDULIDÆ.

JJ. Anterior coxæ either globose or oval.

K. Anterior coxæ globose.

L. Tarsi slender. p. 535....ENDOMYCHIDÆ.

LL. Tarsi more or less dilated and spongy beneath. p. 536.....EROTYLIDÆ.

KK. Anterior coxæ oval.

L. Anterior coxæ separated by the horny prosternum.

M. Body depressed, head free. p. 538. MYCETOPHAGIDÆ.

MM. Body cylindrical, thorax prolonged over the head. p. 554.....CIIDÆ.

LL. Anterior coxæ contiguous, prosternum semimembranous. p. 543....GEORYSSIDÆ.

BB. Hind tarsi with only four segments, the fore tarsi, and almost always the middle tarsi also, with five segments.

C. Anterior coxal cavities closed behind.

D. Tarsal claws simple.

E. Abdomen with five ventral segments.

F. Ventral abdominal segments in part grown together.

G. Next to the last segment of tarsi spongy beneath. p. 584.... .....LAGRIIDÆ.

GG. Penultimate segment of tarsi not spongy. p. 582. TENEBRIONIDÆ

FF. Ventral abdominal segments free.

G. Anterior coxal cavities confluent. p. 584. OTHNIIDÆ.

GG. Anterior coxal cavities separated by the prosternum.

H. Elytra truncate, tip of abdomen exposed. (*Rhizophagus.*) p. 541..... ...NITIDULIDÆ.

HH. Elytra entire. p. 554.....SPHINDIDÆ.

EE. Abdomen with six ventral segments.

F. The first two ventral abdominal segments grown together; the last two closely united. p. 584.ÆGIALITIDÆ.

FF. Ventral abdominal segments free. p. 529. SILPHIDÆ.

DD. Tarsal claws pectinate. p. 584.....CISTELIDÆ.

CC. Anterior coxal cavities open behind.

D. Head not strongly and suddenly constricted at base.

E. Middle coxæ not very prominent.

F. Antennæ received in grooves. p. 584...MONOMMIDÆ.

FF. Antennæ free.

G. Prothorax margined at the sides.

H. Middle coxal cavities entirely surrounded by the sterna. p. 538.....CRYPTOPHAGIDÆ.

HH. Epimera of mesothorax reaching the coxæ.

I. Metasternum long; epimera of metathorax visible. p. 585..... .....MELANDRYIDÆ.

II. Metasternum quadrate; epimera of metathorax covered. p. 537.....CUCUJIDÆ.

GG. Prothorax not margined at the sides. p. 585. PYTHIDÆ.

EE. Middle coxæ very prominent. p. 585...ŒDEMERIDÆ.

DD. Head strongly constricted at base.

E. Head prolonged behind and gradually narrowed. p. 585. CEPHALOIDÆ.

EE. Head suddenly narrowed behind.

F. Prothorax with the side pieces not separated from the pronotum by a suture.

G. Tarsi perfect, with distinct claws; eyes normal.

H. Prothorax at base narrower than the elytra.

I. Hind coxæ not prominent, or but slightly so.

J. Anterior coxæ globular, not prominent. p. 537. CUCUJIDÆ.

JJ. Anterior coxæ conical, prominent. p. 586. ANTHICIDÆ.

II. Hind coxæ large, prominent.

J. Tarsal claws simple; head horizontal. p. 586. PYROCHROIDÆ.

JJ. Claws cleft or toothed; front vertical. p. 586. MELOIDÆ.

HH. Prothorax, at base, as wide as the elytra. p. 589. RHIPIPHORIDÆ.

GG. Tarsi without claws; eyes pedunculated. p. 589. STYLOPIDÆ.

FF. Lateral suture of prothorax distinct; base of prothorax as wide as the elytra.

G. Antennæ filiform.

H. Hind coxæ plate-like. p. 586. ....MORDELLIDÆ.

HH. Hind coxæ, not plate-like. p. 585. MELANDRYIDÆ.

GG. Antennæ flabellate in the male, subserrate in the female. p. 589..... .....RHIPIPHORIDÆ.

AA. Head more or less prolonged into a beak; palpi short and rigid; gular sutures confluent on the median line (Fig. 602, *gs*); prosternal sutures wanting; the epimera of the prothorax meeting on the middle line behind the prosternum. (Fig. 602, *em*.) RHYNCHOPHORA.

B. Elytra with no fold or with a very feeble one on the lower surface near the outer edge; pygidium of male and female alike.
C. Labrum distinct. p. 590.....RHINOMACERIDÆ.
CC. Labrum wanting.
D. Mandibles flat, toothed on inner and outer sides. p. 591. RHYNCHITIDÆ.
DD. Mandibles stout, pincer-shaped. p. 591...ATTELABIDÆ.
BB. Elytra with a very strong fold on the lower surface near the outer margin.
C. The last dorsal segment (pygidium) of the male divided transversely, so that this sex appears to have one more dorsal segment than the female.
D. Antennæ with a ringed or solid club.
E. Tarsi narrow, setose or spinose beneath. p. 591. BYRSOPIDÆ.
EE. Tarsi usually dilated, brush-like beneath.
F. Mandibles with a deciduous piece, which is lost soon after emergence from the pupa state, and leaves a scar. p. 592.....OTIORHYNCHIDÆ.
FF. Mandibles without accessory piece in the pupa state, and therefore without a scar in the adult state. p. 593. CURCULIONIDÆ.
DD. Antennæ with ten or eleven distinct segments. p. 594. BRENTHIDÆ.
CC. Pygidium of both sexes undivided.
D. Pygidium horizontal; tibiæ usually serrate. p. 596. SCOLYTIDÆ.
DD. Pygidium vertical or declivous; tibiæ not serrate.
E. Antennæ geniculate; labrum wanting; last spiracle covered by ventral segments. p. 595.....CALANDRIDÆ.
EE. Antennæ straight; labrum distinct; last spiracle uncovered. p. 598.....ANTHRIBIDÆ.

Suborder COLEOPTERA GENUINA.

The Typical Coleoptera.

This suborder includes all the families of Coleoptera except the snout-beetles, which are classed together as a second suborder, the Rhynchophora.

In the Typical Coleoptera the mouth-parts are of the ordinary type; the head is not prolonged into a snout; the gula is present, there being two gular sutures, at least, before and behind (Fig. 601, *b*); and the epimera of the prothorax are not prolonged so as to meet on the middle line of the body behind the prosternum (Fig. 612).

Family CICINDELIDÆ (Cic-in-del'i-dæ).

The Tiger-beetles.

The graceful forms and beautiful colors of the greater number of the tiger-beetles have made this family one of the favorites of students of Coleoptera. To this family belong the most agile of all beetles; and they are not merely swift of foot, but are also able to fly well. They are found on bright, hot days in dusty roads, in beaten paths, and on the shores of streams. They remain absolutely still until we can see them well but are still out of reach; then like a flash they fly up and away, alighting several rods ahead of us. Before alighting they always turn so that they face us, and can thus watch our movements.

Their popular name is suggestive of their predaceous habits, and of the spots with which many are marked. They are usually a metallic green or bronze, banded or spotted with yellow. Some are black; and some that live on white sand are grayish white, being exactly like the sand in color.

A useful character for distinguishing the members of this family is the fact that the terminal hook of the maxilla (the *digitus*) is united to this organ by a movable joint (Fig. 618, *h*).

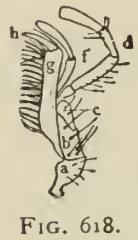

FIG. 618.

The sexes of the tiger-beetles can be distinguished, except in *Amblychila*, by the sixth abdominal segment of the males being notched so as to expose a small seventh segment; while in the females only six segments are visible. In the

males also the first three segments of the anterior tarsi are usually dilated and densely clothed with hair beneath.

It has been said that these beetles make burrows in which to retire from the rain and cold. We have seen them in September digging burrows in a hillside; these descended slightly and were about five inches deep. The beetles kicked the dirt out behind them as they dug, so that it lay in a heap at the opening of the hole. But we were unable to discover whether these burrows were made as dwellings, or, what is more likely, places in which to deposit eggs. No observation as to the egg-laying habits of these insects has come to our notice.

The tiger-beetle larvæ (Fig. 619) are as ugly and ungraceful as the adults are beautiful. The two have only one habit in common—their eagerness for prey. The larvæ live in vertical burrows in sandy places or in beaten paths. These burrows occur also in ploughed fields that have become dry and hard. They often extend a foot or more in depth. The larva takes a position of watchfulness at the mouth of its burrow. Its dirt-colored head is bent at right angles to its lighter-colored body and makes a neat plug to the opening of the hole. Its rapacious jaws extend upward, wide open, ready to seize the first unwary insect that walks over this living trap. On the fifth segment of the abdomen there is a hump, and on this hump are two hooks curved forward. This is an arrangement by which the little rascal can hold back and keep from being jerked out of its hole when it gets some large insect by the leg, and by which it can drag its struggling prey down into its lair, where it may eat it at leisure. It is interesting to thrust a straw down into one of these burrows, and then dig it out with a trowel. The chances are that you will find the indignant inhabitant at the remote end of the burrow, chewing savagely at the end of the intruding straw.

FIG. 619.—Larva of *Cicindela*.

Nearly all of our tiger-beetles belong to the genus *Cicindela* (Cic-in-de'la), of which there are about sixty North American species; one of these is represented in Figure 620. We have also two species of *Tetracha* (Tet'ra-cha); see Figure 621. In the Middle West is found *Amblychila cylindriformis* (Am-bly-chi'la cy-lin-dri-for'mis), the giant of the family, measuring one and three eighths inches in length; and on the Pacific coast occur nine species of *Omus* (O'mus). In this genus the body is smaller and its thorax larger than in *Cicindela*. These beetles search for their prey only at night.

FIG. 620.

FIG. 621.

Family CARABIDÆ (Ca-rab'i-dæ).

The Ground-beetles.

The ground-beetles are so called because they are very common on the surface of the ground, lurking under stones or rubbish, or running through the grass. Our more common species are easily recognized by their shining-black color and long legs. On the Pacific coast, however, the darkling beetles (Family Tenebrionidæ), which are also black and have long legs, abound under stones and fragments of wood on the ground. But the two families can be easily distinguished by the fact that in the ground-beetles all the tarsi are five-jointed, while in the darkling beetles the hind tarsi are only four-jointed; and the darkling beetles do not run rapidly as do the ground-beetles.

With the ground-beetles the antennæ are thread-like, tapering gradually towards the tip, and each segment is of nearly uniform thickness throughout its length; the legs are fitted for running, and the antennæ are inserted between the base of the mandibles and the eyes. Although most of the species are black, there are those that are blue, green, or brown, and a few that are spotted. The wing-covers are

almost always ornamented with longitudinal ridges and rows of punctures.

Most members of this family are predaceous, feeding upon other insects, which they spring upon or capture by chase. A few species use vegetable food; but their depredations are rarely of economic importance. As there are more than eleven hundred described North American species, and as many of the species are very common, this family may be considered the most important family of predaceous insects.

The larvæ of ground-beetles are generally long, with the body of nearly equal breadth throughout (Fig. 622.) They have sharp projecting mandibles; and the caudal end of the body is usually furnished with a pair of conical bristly appendages. They live in the same obscure situations as the adult insects, but are more shy, and are consequently less frequently seen. Like the adults, they are predaceous.

FIG. 622.

Among the more common ground-beetles are the following:—

The Searcher, *Calosoma scrutator* (Cal-o-so'ma scru-ta'-tor).—This is one of the larger and more beautiful of our ground-beetles; it has green or violet wing-covers margined with reddish, and the rest of the body is marked with violet-blue, gold, green, and copper (Fig. 623). This beetle and the following have been known to climb trees in search of caterpillars.

FIG. 623.

The Fiery Hunter, *Calosoma calidum* (C. cal'i-dum), is somewhat smaller than the preceding, and is easily recognized by the rows of reddish or copper-colored pits on the wing-covers (Fig. 624).

There are certain other large, swiftly running ground-beetles which resemble somewhat those just described. These belong to the genus *Cychrus* (Cy′chrus), and may be recognized by the long, narrow head, the wider or more nearly circular wing-covers, and by the fact that the wing-covers have a very broad, reflected margin, which covers a large part of the sides of the thorax.

Fig. 624.

The bombardier-beetles, *Brachinus* (Bra-chi′nus).—There are many species of beetles that have at the hind end of the body little sacs in which is secreted a bad-smelling fluid, which is used as a means of defence. These beetles spurt this fluid out on to their enemies when attacked. But in the case of the bombardier-beetles this fluid changes to a gas, which looks like smoke as soon as it comes in contact with the air, and is ejected with a sound like that of a tiny pop-gun. When some larger insect tries to capture one of these insect-soldiers, and gets very near it, the latter fires its little gun into the face of its enemy. The noise astonishes the pursuer, and the smoke blinds him. By the time he has recovered from his amazement, the little bombardier is at a safe distance. These beetles have quite a store of ammunition; for we have often had one pop at us four or five times in succession, while we were taking it prisoner. The bombardier-beetles belong to the genus *Brachinus*, of which we have in this country about twenty-five species. They are very similar in appearance; the head, prothorax, and legs are reddish yellow, and the wing-covers are dark blue, blackish, or greenish blue (Fig. 625).

Fig. 625.

There is a common beetle that resembles the bombardier-beetles quite closely in size and color, but which may be distinguished by the comb-like form of the tarsal claws; this is *Lebia grandis*

(Le'bi-a gran'dis) (Fig. 626). It has been reported more often than any other insect as destroying the Colorado Potato-beetle.

Galerita janus (Gal-e-ri'ta ja'nus) is still another species that bears some resemblance to the bombardier-beetles. But it is much larger, measuring two thirds of an inch in length, and has only the prothorax and legs reddish yellow, the head being black; the prothorax is only about half as wide as the wing-covers.

FIG. 626.—*Lebia grandis*. natural size and enlarged.

What is perhaps the most common type of ground-beetle is illustrated by *Harpalus caliginosus* (Har'pa-lus ca-lig-i-no'sus), which is represented natural size by Figure 627. It is of a pitchy black color, and is one of the most common of our larger species. There are nearly fifty other species of this genus in this country. Most of them are smaller than this one, are flattened, and have the prothorax nearly square.

FIG. 627.

The beetles of the genus *Dicælus* (Di-cæ'-lus) are quite common; and some of the larger species resemble *Harpalus caliginosus* quite closely. They can be distinguished by a prominent keel-shaped ridge which extends back upon each wing-cover from near the corner of the prothorax.

The most common of all ground-beetles, in the Northeastern States at least, is *Pterosticus lucublandus* (Pte-ros'ti-cus lu-cu-blan'dus). In this species (Fig. 628) the narrow, flat margin on each side of the prothorax is widened near the hinder angle of this segment.

FIG. 628.

The family AMPHIZOIDÆ (Am-phi-zo'i dæ) is represent-

ed in our fauna by two species of *Amphizoa* (Am-phi-zo'a), which occur in Northern California, Utah, and Vancouver, clinging to logs or stones under the surface of streams. In these beetles the metasternum is truncate behind, not reaching the abdomen, and has a very short antecoxal piece.

Family HALIPLIDÆ (Ha-lip'li-dæ).

The Haliplids (*Hal'i-plids*).

This family includes a few species of small aquatic beetles, which are oval, more or less pointed at each end, and very convex. The wing-covers have rows of punctures, and the hind coxæ are greatly expanded so as to conceal the basal half of the hind femora and from three to six of the abdominal segments.

These beetles are not uncommon in ponds and streams, but they swim poorly. Only three genera occur in this country. In *Brychius* (Brych'i-us), which is represented by one species from California, the prothorax is quadrate; in the other genera it is narrowed in front. In *Haliplus* (Hal'-i-plus) the last segment of the palpi is small and awl-shaped; in *Cnemidotus* (Cnem-i-do'tus) it is longer than the third segment, and conical.

The larvæ are aquatic, occurring near the shores of ponds and streams and in other damp places. The body is rather slender; each segment except the head is furnished on the back with fleshy lobes with spiny tips, which vary greatly in size in different species; and the last segment bears a long tapering appendage. Figure 629 represents a larva of this family, which we found in large numbers in a pond swarming with *Cnemidotus;* it probably belongs to this genus. The larvæ of several species of *Haliplus* are figured by Schiotde, but in each of these the caudal appendage is forked.

FIG. 629.

Family DYTISCIDÆ (Dy-tis'ci-dæ).

The Predaceous Diving-beetles

If one will approach quietly a pool of standing water, there may be seen oval, flattened beetles hanging head downward, with the tip of the abdomen at the surface of the water. Such beetles belong to this family.

The predaceous diving-beetles are usually brownish black and shining, but are often marked indefinitely with dull yellow. They can be distinguished from the water scavenger-beetles, which they resemble in general appearance, by the thread-like form of the antennæ. The hind legs are the longest, and are fitted for swimming, being flattened, and fringed with hair. The middle and the hind pairs of legs are widely separated. This is due to the very large hind coxæ which cover the greater part of the lower surface of the thorax. In the males of certain genera the first three segments of the fore tarsi are dilated and form a circular disk, upon the under side of which are little cup-like suckers (Fig. 630). In a few cases the middle tarsi are dilated also. The females of some species exhibit an interesting dimorphism in that some of the individuals have the elytra furnished with a number of deep furrows (Fig. 631), while others of the same species have them smooth.

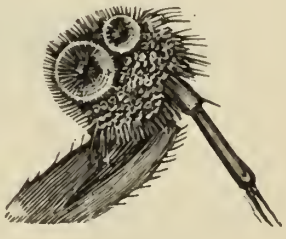

FIG. 630.

FIG. 631.

The diving-beetles abound in our streams and ponds, but they are more often found in standing water than in streams. When at rest they float in an inclined position, head downward, with the tip of the hind end of the body projecting from the water. The spiracles open on the dorsal side of the abdomen beneath the elytra. By lifting the elytra slightly a reservoir is formed for air, which the beetle can breathe as it swims through the water. When

the air becomes impure the beetle rises to the surface, forces it out, and takes a fresh supply.

These beetles are very voracious. They destroy not only other insects, but some of them will attack larger animals, as small fish. When kept in aquaria they can be fed upon any kind of meat, raw or cooked. They fly from pond to pond, and are often attracted to lights at night. Many of the species make sounds, both under the water and in the air. In some cases this is done by rubbing the abdominal segments upon the elytra; in others, by rubbing the hind legs upon a rough spot on the lower side of the abdomen.

The females deposit their eggs at random in the water. The larvæ are known as water-tigers, because of their bloodthirstiness. They are elongated, spindle-form grubs (Fig. 632). The head is large, oval or rounded, and flattened;

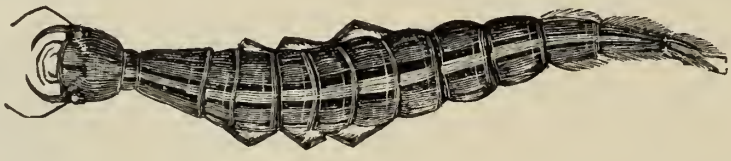

FIG. 632.

the mandibles are large, sickle-shaped, and hollow, with a slit-like opening near the tip; they are admirably fitted for holding the prey, and at the same time sucking the juices from its body, the hollow of the mandibles communicating with the œsophagus. The true mouth is quite small. The thorax is furnished with six well-developed legs. With many of these larvæ the body ends in a pair of breathing-tubes, which they protrude into the air at intervals.

When a larva is fully grown it leaves the water, burrows into the ground, and makes a round cell, within which it undergoes its transformations. The pupa state lasts about three weeks in summer; but the larvæ that transform in autumn remain in the pupa state all winter.

This is the largest of the families of water-beetles; nearly three hundred North American species are known.

The best way to obtain specimens is to sweep the vegetation growing on the bottom of a quiet pool with a dip-net.

The larger of our common species belong to *Cybister* (Cy-bis'ter), *Dytiscus* (Dy-tis'cus), and allied genera. In *Cybister* the little cups on the under side of the tarsal disks of the male are similar, and arranged in four rows. In *Dytiscus* and its allies the cups of the tarsal disks vary in size. Figure 633 represents a common species of *Dytiscus*.

FIG. 633.

The most common of the diving-beetles that are of medium size belong to the genus *Acilius* (A-cil'i-us). In this genus the elytra are densely punctured with very fine punctures, and the females usually have four furrows in each wing-cover (Fig. 631).

There are also common diving-beetles that are of about the same size as the preceding, but which have the wing-covers marked with numerous very fine transverse striæ; these belong to the genus *Colymbetes* (Col-ym-be'tes).

Of the smaller diving-beetles, measuring less than one fourth of an inch in length, many species can be found in almost any pond. These represent many genera.

Family GYRINIDÆ (Gy-rin'i-dæ).

The Whirligig-beetles.

As familiar to the country rover as the gurgling of the brook, or the flecks of foam on its "golden-braided centre," or the trailing ferns and the rustling rushes on its banks, are these whirligigs on its pools. Around and around each other they dart, tracing graceful curves on the water, which vanish almost as soon as made. They are social fellows, and are almost always found in large numbers, either swimming or resting motionless near together. They rarely dive, except when pursued; but are so agile that it is extremely

difficult to catch them without a net. Many of them when caught exhale a milky fluid having a very disagreeable odor. They feed upon small flies, beetles, and other insects that fall into the water, and are furnished with well-developed wings, with which they fly from one body of water to another.

This is one of the most easily-recognized families of the whole order Coleoptera. The members of it are oval or elliptical in form (Fig. 634), more or less flattened, and usually of a very brilliant, bluish-black color above, with a bronze metallic lustre. The fore legs are very long and rather slender; the middle and hind legs are short, broad, and very much flattened. These insects are remarkable for having the eyes completely divided by the margin of the head, so that they appear to have four eyes—a pair upon the upper surface of the head with which to look into the air, and a pair upon the under side for looking into the water. The antennæ are very short and peculiar in form. The third segment is enlarged, so as to resemble an ear-like appendage, and the following ones form a short, spindle-shaped mass. They are inserted in little cavities in front of the eyes.

FIG. 634.

The eggs of these insects are small, of cylindrical form, and are placed end to end in parallel rows upon the leaves of aquatic plants. The larvæ (Fig. 635) are long, narrow, and much flattened. Each abdominal segment is furnished with a pair of tracheal gills, and there is an additional pair at the caudal end of the body. The elongated form of the body and the conspicuous tracheal gills cause these larvæ to resemble small centipedes. When a larva is full grown it leaves the water and spins a gray, paper-like cocoon attached to some object near the water. The pupa state of the species in which it has been observed lasts about a month.

FIG. 635.

The family is a small one. At present only thirty-six

North American species are known. These represent three genera. The genus *Gyretus* (Gyr'e-tus) is distinguished by having the last ventral segment of the abdomen elongated and conical. It is represented by a single species, *G. sinuatus* (G. sin-u-a'tus). In the other two genera the last ventral segment is flattened and rounded at the tip. In *Dineutus* (Di-neu'tus) the scutellum is wanting; there are eight species of this genus. In *Gyrinus* (Gy-ri'nus) the scutellum is visible; of this genus we have twenty-seven species.

Family HYDROPHILIDÆ (Hyd-ro-phil'i-dæ).

The Water-scavenger Beetles.

The water-scavenger beetles are common in quiet pools, where they may be found swimming through the water, or crawling among the plants growing on the bottom. They can be easily taken by sweeping such plants with a dip-net.

They are elongated, elliptical, black beetles, resembling the predaceous diving beetles in appearance; but they are usually more convex, and differ also in having club-shaped antennæ and very long palpi. As the antennæ are usually concealed beneath the head, it often happens that the inexperienced student mistakes the long palpi for antennæ.

These beetles are supposed to live chiefly upon decaying vegetation in the water; but a number of species have been known to catch and eat living insects. They breathe by carrying a film of air on the lower surface of the body. This film gives them a silvery appearance when seen from below. They obtain the air by bringing the head to the surface of the water and projecting the antennæ, which they again fold back with a bubble of air when they descend. The female makes a case for her eggs out of a hardened silk-like secretion. Some species deposit as many as a hundred eggs in one of these waterproof packages (Fig. 636). The egg-cases in some instances are fastened beneath the leaves of aquatic

FIG. 636.

plants; in others they are provided with floats and let loose in the water; and in still other species the cases are carried by the mother underneath her body and steadied with her hind legs. Frequently some of the young larvæ devour their companions; in this way the size of the family is decreased before it escapes from the egg-case. Later they live upon insects that fall into the water and upon snails.

These larvæ resemble somewhat those of the Dytiscidæ; but the body is much more plump, and the mandibles are of moderate size. A very interesting observation on the mode of feeding of one of these larvæ has been published. It captured a fly, and swam with it rapidly through the water to a leaf near the surface. It then rested on this leaf, and, raising its head out of the water, crushed the fly to pulp with its jaws, letting the blood run into its open mouth.

The Hydrophilidæ are represented in North America by about one hundred and fifty species. Our three largest belong to the genus *Hydrophilus* (Hy-droph'i-lus). In this genus the metasternum is prolonged backward into a spine between the hind legs, and the sternum of the prothorax bears a deep furrow. Our most common species is *Hydrophilus triangularis* (H. tri-an-gula'ris) (Fig. 637).

Fig. 637.

The beetles of the genus *Tropisternus* (Trop-i-ster'nus) agree with *Hydrophilus* in the form of the prosternum and metasternum, but differ in size, our species measuring less than one-half inch in length. The most common species in the East is *Tropisternus glaber* (T. gla'ber), and, on the Pacific coast, *T. californicus*.

Next in size to *Hydrophilus* are several species of *Hydrocharis* (Hy-droch'a-ris). In this genus the metasternum is prolonged somewhat, but does not form a long, sharp

spine as in *Hydrophilus* and *Tropisternus*, and the sternum of the prothorax bears a keel-shaped projection. Our most common species is *Hydrocharis obtusatus* (H. ob-tu-sa'tus); this measures about five eighths of an inch in length.

Some of the smaller species of this family are not aquatic, but live in moist earth and in the dung of cattle, where, it is said, they feed on dipterous larvæ.

Family PLATYPSYLLIDÆ (Plat-y-psyl'i-dæ).

The Beaver-parasite.

Only a single representative of this family is known; this is *Platypsylla castoris* (Plat-y-psyl'la cas'to-ris), which lives parasitically on the beaver. This beetle is about one tenth of an inch in length; the body is ovate, elongate, and much flattened; the wing-covers are short, about as long as the prothorax, and leave five abdominal segments exposed; the eyes and wings are wanting.

Specimens of this remarkable insect are most easily obtained by beating over a sheet of paper the dried skins of beavers, which can be found at fur-stores.

The family LEPTINIDÆ (Lep-tin'i-dæ) is represented by only two species in North America. One of these is from the Hudson Bay region; the other, *Leptinus testaceus* (Lep-ti'nus tes ta'ce-us) lives with various small rodents and insectivora, either on their bodies or in the material of their nests. It can be distinguished by the characters given in the table of families.

Family SILPHIDÆ (Sil'phi-dæ).

The Carrion-beetles.

The carrion-beetles are mostly of medium or large size, many species attaining the length of one and one half inches, while the smaller species of the more typical genera are nearly half an inch in length; some members of the family, however, are minute. The segments near the tip of the an-

tennæ are usually enlarged so as to form a compact club, which is neither comb-like nor composed of thin movable plates; sometimes the antennæ are nearly filiform.

These insects usually feed upon decaying animal matter; some, however, feed upon fungi, and a few species have been known to be predaceous when pressed by hunger, destroying living snails and insects—even members of their own species.

It is easy to obtain specimens of these insects by placing pieces of meat or small dead animals in the fields and examining them daily. There are several other families of beetles the members of which can be attracted in this way.

The larvæ also live upon decaying flesh and are found in the same situations as the adults.

We have in this country more than one hundred species of this family. Our larger and more familiar species represent two genera, *Necrophorus* (Nec-roph'o-rus) and *Silpha* (Sil'pha).

The Burying-beetles, *Necrophorus*.—To this genus belong the largest members of the family. The body is very stout, almost cylindrical (Fig. 638). Our common species have a reddish spot on each end of each wing-cover; these spots are often so large that they appear as two transverse bands. In some species the prothorax and the head are also marked with red.

FIG. 638.

These insects are called burying-beetles because they bury carrion. When a pair of these beetles discover a dead bird, mouse, or other small animal, they dig beneath it, removing the earth so as to allow the carrion to settle into the ground. This they will continue until the object is below the surface of the ground. Then they cover it with earth, and finally the female digs down to it and lays

her eggs upon it. The larvæ that hatch from these eggs feed upon the food thus provided for them. There are many accounts of exhibitions of remarkable strength and sagacity by burying-beetles. A pair of these insects have been known to roll a large dead rat several feet in order to get it upon a suitable spot for burying.

The members of the genus *Silpha* are very much flattened (Fig. 639). The prothorax is round in outline, with very thin edges which overlap the wing-covers somewhat. The body is not nearly as stout as that of a burying-beetle, being fitted for creeping under dead animals instead of for performing deeds requiring great strength.

FIG. 639.

In some of the minute members of the family the body is nearly hemispherical.

The family SCYDMÆNIDÆ (Scyd-mæn'i-dæ) includes very small insects found under bark or stones, in ants' nests, or near water. They are small, shining, usually ovate, but sometimes slender insects, of a brown color, and more or less clothed with erect hairs. Other characters are given in the preceding table of families. Nearly fifty North American species are known.

The family PSELAPHIDÆ (Pse-laph'i-dæ) includes certain very small beetles, the larger ones not exceeding one eighth inch in length. They resemble rove-beetles in the shortness of the wing-covers and in having the dorsal part of the abdominal segments entirely horny; but they differ from them in that the abdomen is not flexible, and in having fewer abdominal segments, there being only five or six on the ventral side. The species are of a chestnut-brown color and usually slightly pubescent. The elytra and abdomen are convex and usually wider than the head and prothorax. These beetles are found under stones and bark, or in ants-nests, or flying in the twilight. Nearly one hundred and fifty species are known from North America.

Family STAPHYLINIDÆ (Staph-y-lin'i-dæ).

The Rove-beetles.

The rove-beetles are very common about decaying animal matter, and are often found upon the ground, under stones or other objects. They are mostly very small insects; a few species, however, are of larger size, measuring a half inch or more in length. Their appearance is very characteristic, the body being long and slender, and the wing-covers very short (Fig. 640). The wings, however, are fully developed, often exceeding the abdomen in length; when not in use the wings are folded beneath the short wing-covers. The abdominal segments are freely movable, and are seven or eight in number.

FIG. 640.

It is interesting to watch one of these insects fold its wings; frequently they find it necessary to make use of the tip of the abdomen or of one of the legs in order to get the wings folded beneath the wing-covers.

The rove-beetles can run quite swiftly; and they have the curious habit, when disturbed, of raising the tip of the abdomen in a threatening manner, as if they could sting. As some of the larger species resemble wasps somewhat in the form of the body, these threatening motions are often as effective as if the creature really had a sting.

As these insects feed upon decaying animal and vegetable matter, they should be classed as beneficial. The larvæ resemble the adults in the form of the body and are found in similar situations.

About one thousand North American species of rove-beetles have been described. The great majority of them are small and exceedingly difficult to determine. Among the large species that are common are the following:—

Creophilus villosus (Cre-oph'i-lus vil-lo'sus).—This species varies from one-half inch to nearly an inch in length. It is of a shining black color, spotted with patches of fine gray

hairs. There is a conspicuous band of these across the middle of the wing-covers, and another on the second and third abdominal segments; this abdominal band is best marked on the lower side of the body.

Staphylinus maculosus (Staph-y-li'nus mac-u-lo'sus) is a larger species, which often measures fully an inch in length. It is densely punctured, and of a dull-brown color, with the scutellum black, and a row of obscure, square, blackish spots along the middle of the abdomen.

Staphylinus vulpinus (S. vul-pi'nus) resembles the preceding somewhat, but it has a pair of bright-yellow spots at the base of each abdominal segment.

Leistotrophus cingulatus (Leis-tot'ro-phus cin-gu-la'tus) is of about the same size as the preceding. It is brown, speckled with brownish-black spots, and the tip of its abdomen is clothed with golden hairs.

The family TRICHOPTERYGIDÆ (Tri-chop-te-ryg'i-dæ), or *the Feather-wing Beetles*, includes the smallest beetles that are known; most of our species are less than one twenty-fifth of an inch in length, and in many cases they are not half that size. The most striking feature of the typical forms is the shape of the wings, which are long, narrow, and fringed with long hairs, being feather-like in appearance; but in some species the wings are wanting. Some species live in rotten wood, muck, manure, and other decaying organic matter; a few have been found in ants' nests.

The family HYDROSCAPHIDÆ (Hyd-ro-scaph'i-dæ) is represented in America by a single, minute, aquatic species from California. See table of families for its characteristics.

The family SPHÆRIIDÆ (Sphae-ri'i-dæ) is also represented on this continent by a single Californian species. It lives in mud or under stones near water. Its distinguishing features are given in the table of families.

The family SCAPHIDIIDÆ (Scaph-i-di'i-dæ) includes less than twenty known North American species. They are

small, oval, very shining insects, found in fungi and rotten wood. The elytra are broadly truncate behind, not covering the entire abdomen.

The family PHALACRIDÆ (Pha-lac'ri-dæ) includes a small number of very small, convex, shining black beetles, which are sometimes two-spotted or tipped with red. They are found on flowers and sometimes under bark.

The family CORYLOPHIDÆ (Cor-y-loph'i-dæ) includes minute beetles found under damp bark and in decaying vegetable matter. The body is oval or rounded, and in many species is clothed with a grayish pubescence. The wings are wide, and fringed with long hairs. About twenty-five North American species are known.

Family COCCINELLIDÆ (Coc-ci-nel'li-dæ).

The Lady-bugs.

These insects are well known to nearly every child under the popular name given above. They are more or less nearly hemispherical, generally red or yellow, with black spots, or black, with white, red, or yellow spots.

The larvæ occur running about on foliage; they are often spotted with bright colors and clothed with warts or with spines (Fig. 641). When ready to change to a pupa the larva fastens itself by its tail to any convenient object, and the skin splits open on the back. Sometimes the pupa state is passed within this split skin, and sometimes the skin is forced back and remains in a little wad about the tail (Fig. 642).

FIG. 641.

FIG. 642.

With very few exceptions, the lady-bugs are predaceous, both in the larval and adult states. They feed upon small insects and upon the eggs of larger species. The larvæ of certain species are known as "niggers" by hop-growers, and are greatly prized by them; for they are very destructive to the hop-louse. On the Pacific coast the lady-bugs are well known as the most beneficial of all insects

to the fruit-growers. Nothing more wonderful has been accomplished in economic entomology than the subduing in California of the cottony-cushion scale by the introduction from Australia of a lady-bug, *Vedalia* (Ve-da'li-a), which feeds upon it.

Next in importance to the Vedalia on the Pacific coast are the twice-stabbed lady-bugs. Several species that occur on both sides of the continent are included under this popular name. They are black, with a bright-yellow or reddish spot on each wing-cover. They are especially prized in California as they feed on the pernicious scale, the black scale, and other destructive species.

A very common lady-bug in the East is *Adalia bipunctata* (A-da'li-a bi-punc-ta'ta). This species is figured on Plate I, Figure 3. It is reddish yellow above, with the middle of the prothorax black, and with a black spot on each wing-cover. It frequently passes the winter in our dwellings, and is found on the walls and windows in early spring. Under such circumstances it is often mistaken for the carpet-beetle and, unfortunately, destroyed.

The Nine-spotted Lady-bug, *Coccinella novemnotata* (Coc-ci-nel'la no-vem-no-ta'ta) has yellowish wing-covers, with four black spots on each, in addition to a common spot just back of the scutellum (Fig. 643).

FIG. 643.

The Herbivorous Lady-bug, *Epilachna borealis* (Ep-i-lach'na bor-e-a'lis), presents a remarkable exception in habits to what is the rule in this family. The larva of this species is herbivorous, feeding on the leaves of squash, pumpkin, and allied plants. It is yellow and is clothed with forked spines (Fig. 644). A pupa is shown in the figure near the upper right-hand corner. The adult is yellowish, with large black spots.

The family ENDOMYCHIDÆ (En-do-mych'i-dæ) includes a small number of species which are found chiefly in fungi. The body is usually more elongate than in the preceding

family; the antennæ are about half as long as the body; the prothorax is nearly square, and usually has a wide, thin margin, which is slightly turned upwards at the sides.

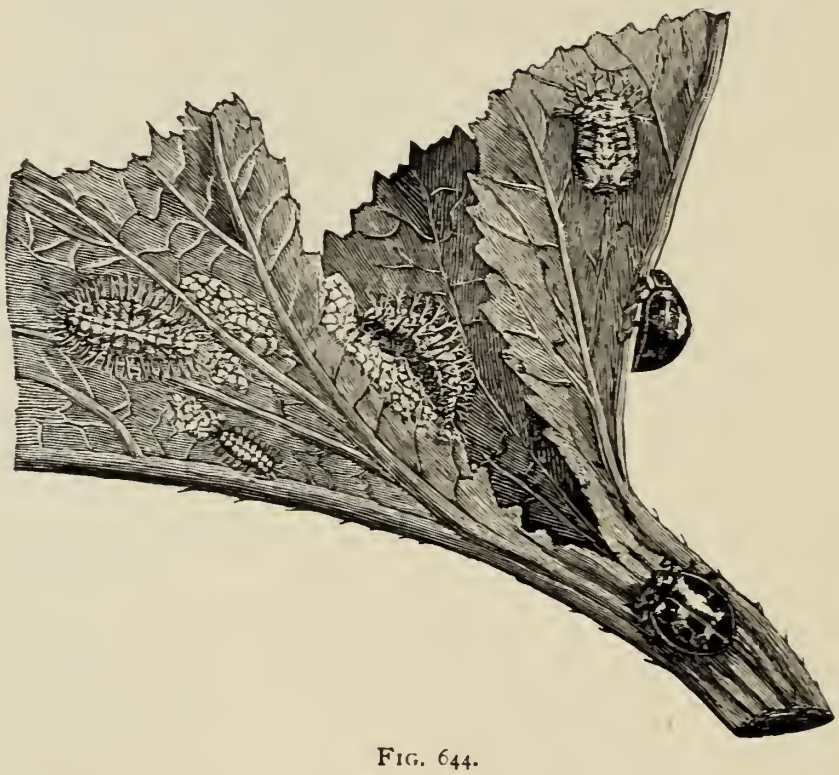

FIG. 644.

Family ÈROTYLIDÆ (Er-o-tyl′i-dæ).

The Erotylids (*Er-ot′y-lids*).

The members of this family are usually of moderate or small size; but some species are quite large, measuring three fourths inch or more in length. Some of our more common species are conspicuously marked with shining black and red.

To the genus *Megalodachne* (Meg-a-lo-dach′ne) belong two common, large species, which are black, with two dull-red bands extending across the wing-covers. *M. heros* (M.he′ros) (Fig. 645) is two thirds of an inch or more in length. *M. fasciata* (M. fas-ci-a′ta) is about half an inch long.

FIG. 645.

The genus *Languria* (Lan gu′ri-a) includes long, narrow species, which resemble click-beetles in form.

Figure 646 represents *L. mozardi* (L. mo-zar'di) greatly enlarged. This is a reddish species with dark-blue wing-

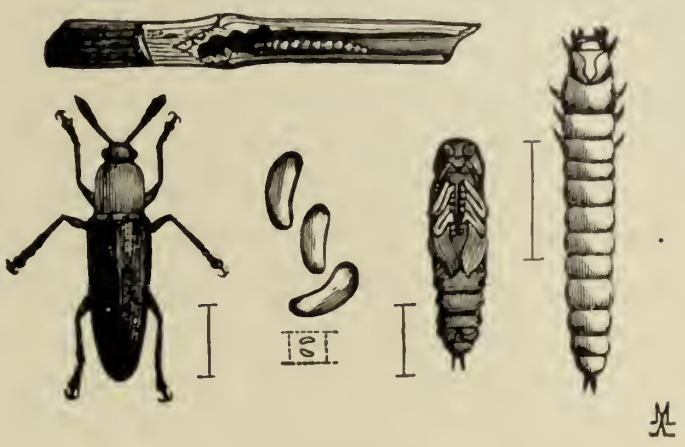

FIG. 646.

covers; the larva bores in the stalks of clover.

The family COLYDIIDÆ (Col-y-di'i-dæ) is composed of small insects which are usually of an elongate or cylindrical form, and are found under bark, in fungi, and in earth. Some of the species are known to be carnivorous, feeding on the larvæ of wood-boring beetles. The tarsi are four-jointed; the tibiæ are not fitted for digging, and the first four abdominal segments are grown together on the ventral side. More than fifty North American species are known.

The family RHYSSODIDÆ (Rhys-sod'i-dæ) includes only four species, two from each side of the continent. They are elongate, somewhat flattened beetles, with the head and prothorax deeply furrowed with longitudinal grooves. They are found under bark.

Family CUCUJIDÆ (Cu-cu'ji-dæ).

The Cucujids (*Cu'cu-jids*).

The insects of this family are very flat and usually of an elongate form; most of the species are brown, but some are of a bright red color. As a rule they are found under bark and are believed to be carnivorous both in the larval and adult states; but some feed in grain.

The most conspicuous of our common species is *Cucujus clavipes* (Cu'cu-jus clav'i-pes) (Fig. 647). This insect is about one half inch in length and of a bright red color, with the eyes and antennæ black and the tibiæ and tarsi dark.

FIG. 647.

The most important member of this family is the Corn Silvanus, *Silvanus surinamensis* (Sil-va'-nus sur-i-na-men'sis), which is one of the small beetles that infest stored grain. This species is readily distinguished from other small beetles with similar habits by its flattened form and the saw-like edges of the prothorax. Besides grain it often infests dried fruits and other stores. It measures from one tenth to one eighth of an inch in length.

The family CRYPTOPHAGIDÆ (Cryp-to-phag'i-dæ) includes insects of small size, usually less than one tenth of an inch in length, and of variable form, but never very flat. The thorax is nearly or quite as wide as the wing-covers and the first ventral abdominal segment is somewhat longer than the others. They are generally of a light yellowish-brown color, and live on fungi and decomposing vegetable matter.

The family MYCETOPHAGIDÆ (My-cet-o-phag'i-dæ) is composed of small, oval, rarely elongate, moderately convex beetles. They are densely punctured and hairy, and are usually prettily marked insects. They live on fungi and under bark.

Family DERMESTIDÆ (Der-mes'ti-dæ).

The Dermestids (Der-mes'tids).

There are several families of small beetles that feed on decaying matter, or on skins, furs, and dried animal substances. The most important of these is the Dermestidæ, as several species belonging to this family destroy household stores or goods.

The Dermestids can be distinguished from most of the

other beetles with similar habits by the fact that the wing-covers completely cover the abdomen. They are chiefly small beetles, although one of the common species measures one third inch in length. They are usually oval, plump beetles, with pale gray or brown markings, which are formed by minute scales, which can be rubbed off. These beetles have the habit of pretending that they are dead when they are disturbed; they will roll over on their backs with their legs meekly folded and lie still for a long period.

The larvæ do much more damage than the adults. They are active, and are clothed with long hairs. These hairs are covered throughout their entire length with microscopic barbs.

The Larder Beetle, *Dermestes lardarius* (Der-mes'tes lar-da'ri-us).—This pest of the larder is the most common of the larger members of this family. It is three tenths of an inch long, and black except the basal half of its wing-covers, which are pale buff or brownish yellow. This lighter portion is usually crossed by a band of black spots, three on each wing-cover (Fig. 648). The larva feeds on dead animal matter, as meat, skins, feathers and cheese. It is often a serious pest where bacon or ham are stored. When full grown it is about half an inch in length, dark brown above, whitish below, and rather thickly covered with long, brown hairs. It is said that this insect can be attracted by baits of old cheese, from which they may be gathered and destroyed.

FIG. 648.

The Carpet Beetle, *Anthrenus scrophulariæ* (An-thre'nus scroph-u-la'ri-æ).—During recent years this insect has become the worst of household pests, feeding in its larval state on carpets, woollens, furs, and feathers. The larva is well-known to many housekeepers as the Buffalo-moth. It is a short, fat grub, about one fifth of an inch in length when full grown, and densely clothed with dark brown hairs. It lives in the cracks of floors, near the edges of rooms, and beneath furniture, where it eats holes in the carpet. It also

enters wardrobes and destroys clothing. The adult is a pretty little beetle which may be found in infested houses, in the spring, on the ceilings and windows. It is about one seventh of an inch in length and clothed with black, white, and brick-red scales (Plate I, Fig. 1). There is a whitish spot on each side of the prothorax, and three irregular, whitish spots on the outer margin of each wing-cover; along the suture where the two wing-covers meet there is a band of brick-red scales, which is widened in several places. It is worth while to learn to know this beetle; for a Lady-bug (Plate I, Fig. 3), which often winters in our houses, is frequently mistaken for it. The Carpet Beetle in its adult state feeds on the pollen of flowers. Sometimes it abounds on the blossoms of currant, cherry, and other fruits. The best way to avoid the ravages of this pest is to use rugs instead of carpets, and to trap the larvæ by placing woollen cloths on the floors of closets. By shaking such cloths over a paper once a week the larvæ can be captured.

The change from carpets to rugs is a very desirable one; for carpets that are tacked to the floor and taken up only once or twice a year are unwholesome. The change need not be a very expensive one. As carpets wear out they may be replaced with rugs; and good carpets can be made over into rugs. If the floors are not polished as is usually the case where it was planned to cover them with carpets, they can be made presentable by filling the cracks with putty and painting the boards where they are to be exposed.

The museum pests, *Anthrenus varius* (An-thre′nus va′-ri-us) and *Anthrenus museorum* (A. mu-se-o′rum).—There are two minute species of this family that are a constant source of annoyance to those having collections of insects.

The adult beetles measure less than one eighth of an inch in length, and are very convex. They deposit their eggs on specimens in our collections; and the larvæ feed upon the specimens, often destroying them. In order to preserve a collection of insects it is necessary that they should be kept

in tight cases, so that these pests cannot gain access to them. Specimens should not be left exposed except when in use. And the entire collection should be carefully examined at least once a month. The injury is done by the larvæ, which are small, plump, hairy grubs. Their presence is indicated by a fine dust that falls on to the bottom of the case from the infested specimens. These larvæ can be destroyed by pouring a small quantity of carbon bisulphide into the case, and keeping it tightly closed for a day or two. Benzine poured on a bit of cotton in the box will cause the pests to leave the specimens, when they may be taken from the box and destroyed. But we have found carbon bisulphide the better agent for the destruction of these pests.

The Raspberry Fruit-worm, *Byturus unicolor* (By-tu'rus u-ni-co'lor).—The fruit of the red raspberry is often infested by a small white worm, which clings to the inside of the berry after it is picked. This is the larva of an oval, pale, dull yellow beetle, which is densely clothed with short, fine, gray hairs. The beetle is represented enlarged in Figure 649; it measures about three twentieths of an inch in length. This insect is also injurious in the adult state, as it feeds on the blossoms of the raspberry.

FIG. 649.

The family HISTERIDÆ (His-ter'i-dæ) includes certain easily recognized beetles which are found about carrion and other decomposing substances. They are mostly small, short, rounded, or somewhat square-shaped beetles, of a shining black color, with the-wing covers marked by lines of fine punctures and truncate behind, leaving two segments of the abdomen exposed (Fig. 650). In some species the wing-covers are marked with red.

FIG. 650.

The family NITIDULIDÆ (Nit-i-du'li-dæ) comprises small, somewhat flattened beetles. With many species the prothorax has wide, thin margins, and the wing-covers are more or less truncate, so as to leave the tip of the

abdomen exposed; but sometimes the elytra are entire. The tarsi are usually five-jointed, with the fourth segment very small; they are more or less dilated; the posterior coxæ are flat, not sulcate; the anterior coxæ are transverse; and the abdomen has five free, ventral segments.

FIG. 651.

One of the most common representatives of this family is *Ips fasciatus* (Ips fas-ci-a'tus). (Fig. 651.) It is a shining black species, with two conspicuous, interrupted, reddish bands across the wing-covers.

The family TROGOSITIDÆ (Trog-o-sit'i-dæ) includes oblong, somewhat flattened beetles, of a black or reddish-black color. Most of them live under bark; but some are found in granaries. They differ from members of the preceding family in having slender tarsi, with the first segment very short.

The family MONOTOMIDÆ (Mon-o-tom'i-dæ) is composed of a few small, depressed beetles, found mostly under the bark of trees. The wing-covers are truncate behind, leaving the last abdominal segment exposed.

The family LATHRIDIIDÆ (Lath-ri-di'i-dæ) includes very small beetles, which live under bark and stones and are sometimes caught flying in twilight. They are oblong; the wing-covers are usually wider than the prothorax and entirely cover the abdomen.

The family DERODONTIDÆ (Der-o-don'ti-dæ) is represented by a single species found in the East and two found in Oregon and northward. The eastern species is a small brown beetle with a tubercle on each side inside the eye.

The family BYRRHIIDÆ (Byr'rhi-dæ) or the *pill-beetles* are short, very convex beetles of small or moderate size; some, however, are half an inch in length. The body is clothed with hairs or minute scales. The legs can be folded up very compactly, the tibia usually having a furrow for the reception of the tarsus. These beetles are found upon walks and

at the roots of trees and grass; a few live under the bark of trees.

The family GEORYSSIDÆ (Ge-o-rys'si-dæ) includes only two American species. "They are small, rounded, convex, roughly sculptured, black insects, found at the margin of streams, on wet sand; they cover themselves with a mass of mud, so that no part of the insect is visible." (LeConte and Horn.)

The family PARNIDÆ (Par'ni-dæ) includes small water beetles, in which the legs are not fitted for swimming. The tarsi are five-jointed; the first four segments of the tarsi are short and equal; the fifth is longer than the others conjoined; the tarsal claws are unusually large. The body is clothed with fine, silken hairs, which retain a film of air when the insect is beneath the water. These beetles are found adhering to stones or plants beneath the surface of the water. The larva of *Psephenus lecontei* (Pse-phe'nus le-con'te-i) is common in the East, clinging to the lower surface of stones in rapid streams; and we have found it in muck near a spring. It is very flat and circular in outline (Fig. 652), and measures about five sixteenths of an inch in length. It is rarely recognized as an insect by the young collector. Other larvæ of this family have similar habits, and resemble this species in form except that the margin of the body is notched between the segments.

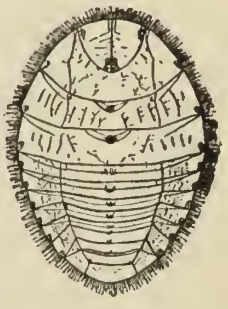

FIG. 652.

The family HETEROCERIDÆ (Het-e-rocer'i-dæ) includes only the genus *Heterocerus* (Het-e-roc'e-rus). These beetles "are oblong or subelongate, oval, densely clothed with short silky pubescence, very finely punctate, and of a brown color, with the elytra usually variegated with undulated bands or spots of a yellow color. They live in galleries which they excavate in sand or mud at the margin of bodies of water, and, when disturbed, run from their galleries and take flight." (LeConte and Horn.)

The family DASCYLLIDÆ (Das-cyl'li-dæ) includes certain beetles that live on plants, usually near the water. The legs are short with slender tibiæ; the tarsi are five-jointed; the posterior coxæ are transverse, and dilated into a plate partly covering the femora; the anterior coxæ are transverse; and the abdomen has five free, ventral segments, the fifth rounded at tip. About fifty species occur in North America. The larvæ, of several species at least, live in rotten wood.

The family RHIPICERIDÆ (Rhip-i-cer'i-dæ) is represented in this country by a very small number of species, which are most commonly found on cedars. The antennæ are serrate in the females, frequently flabellate in the males. The anterior and middle coxæ are conical and prominent, the former with large trochantins; the posterior coxæ are transverse, and dilated into a small plate partly covering the femora.

Family ELATERIDÆ (El-a-ter'i-dæ).

The Click-beetles or Elaters (El'a-ters).

There is hardly a country child that has not been entertained by the acrobatic performances of the long, tidy-appearing beetles called snapping-bugs, click-beetles, or skip-jacks (Fig. 653). Touch one of them and it at once curls up its legs, and drops as if shot; it usually lands on its back, and lies there for a time as if dead. Suddenly there is a click, and the insect pops up into the air several inches. If it comes down on its back, it tries again and again until it succeeds in striking on its feet, and then it runs off.

FIG. 653.

We remember well carrying these creatures into the old district schoolhouse, where all lessons had to be learned from books, and where Nature was never given a chance to teach us anything. Here, with one eye on the teacher and one on this interesting jumper laid on our book behind the desk, we found a most fascinating occupation for the tedious moments. But the end was always the same: the

beetle jumped so high that it betrayed us and was liberated, and we were disgraced.

Our common species of click-beetles are mostly small or of medium size, ranging from one tenth to three fourths of an inch in length. A few species are larger, some reaching the length of nearly two inches. The majority of the species are of a uniform brownish color; some are black or grayish, and some are conspicuously spotted (Fig. 654). The body is elongated, somewhat flattened, and tapers more or less towards each end; the antennæ are moderately elongated, and more or less serrate; the first and second abdominal segments are not grown together on the ventral side; and the hind coxæ are each furnished with a groove for the reception of the femur.

Fig. 654. — A click-beetle. *Drasterius dorsalis*, natural size and enlarged.

The larvæ of click-beetles are long, narrow, worm-like creatures, very even in width, with a very hard covering, and are brownish or yellowish white in color (Figs. 655 and 656). They are commonly known as wire-worms, a name suggested by the form and hardness of the body.

Fig. 655.

Fig. 656.

Some wire-worms live under the bark of trees and in rotten wood; but many of them live in the ground, and feed on seeds and the roots of grass and grain. In fact there is hardly a cultivated plant that they do not infest; and, working as they do beneath the surface of the ground, it is extremely difficult to destroy them. Not only do they infest a great variety of plants, but they are very apt to attack them at the most susceptible period of their growth, before they have attained sufficient size and strength to withstand the attack; and often seed is destroyed before it has germinated. Thus fields of corn or other grain are

ruined at the outset. The appearance of these insects when in the ground, as seen through the glass side of one of our root-cages, is shown in Fig. 657.

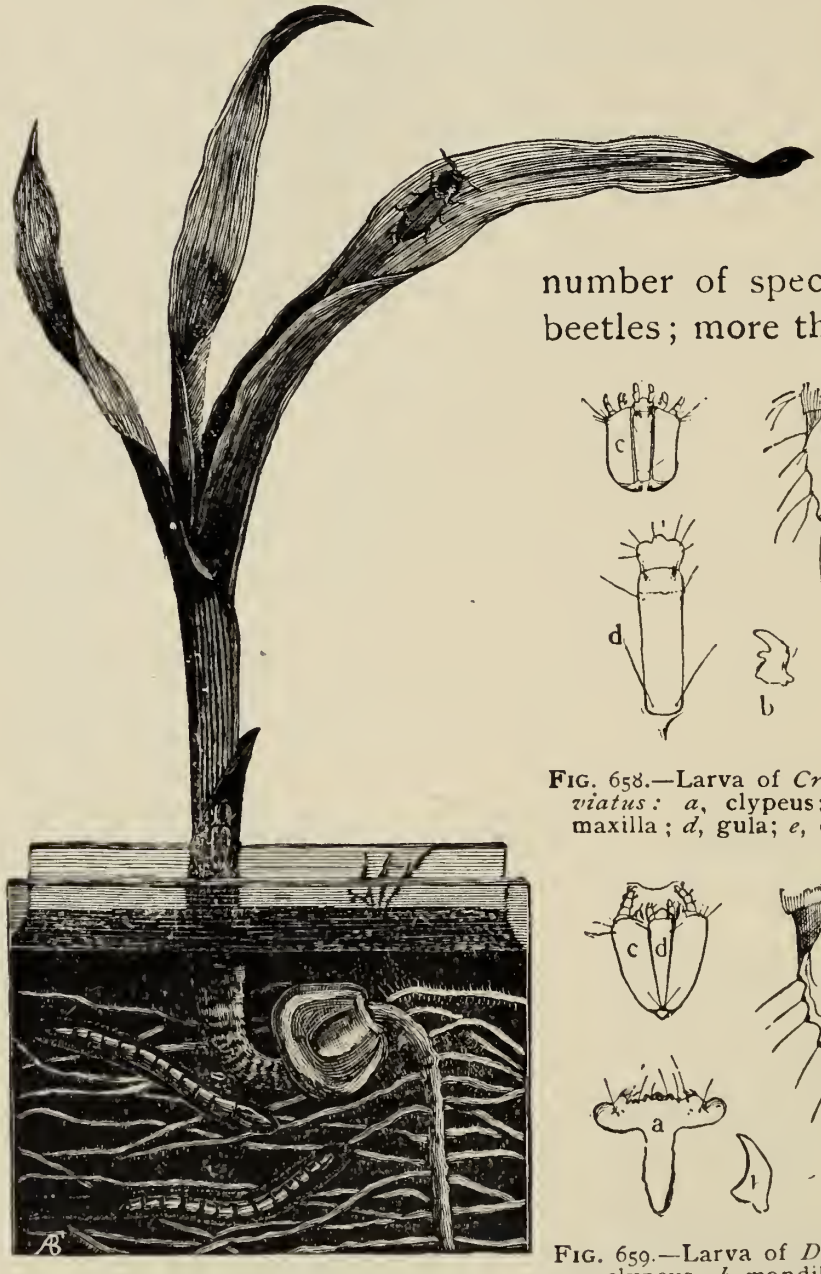

Fig. 657.—A corn-plant growing in a root-cage infested by wire-worms and click-beetles (from a specimen in the Cornell Insectary). The spotted beetle represented near the base of the plant is *Drasterius elegans*; that near the top of the plant is *Agriotes mancus*.

There is a vast number of species of click-beetles; more than five hundred have been described from North America alone. It is quite difficult to separate the closely-allied species, as there is but little variation in shape and color. The larvæ also show comparatively

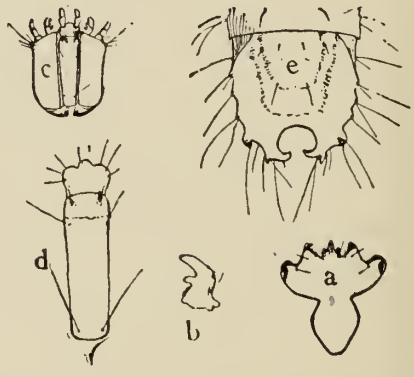

Fig. 658.—Larva of *Cryptohypnus abbreviatus*: *a*, clypeus; *b*, mandible; *c*, maxilla; *d*, gula; *e*, caudal segment.

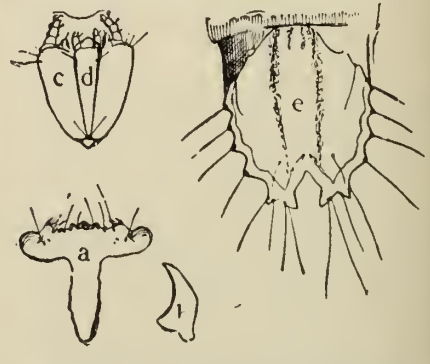

Fig. 659.—Larva of *Drasterius elegans*: *a*, clypeus; *b*, mandible; *c*, maxilla; *d*, gula; *e*, caudal segment.

little variation in form; but in this stage the shape of the parts of the head and the last segment of the body often furnish reliable specific characters (Figs. 658 and 659).

In those species that we have bred it requires several years for the larva to complete its growth. In these species the full-grown larva changes to a pupa in the latter part of the summer, in a little cell in the ground; the pupa soon afterwards changes to an adult; but the adult remains in the cell formed by the larva till the following spring.

Although we tried an extensive series of experiments, extending over several years, we were unable to find any satisfactory way of destroying the larvæ infesting field crops. But we found that if the cells containing pupæ or recently-transformed adults were broken the insects perished. We conclude, therefore, that much can be done towards keeping these insects in check by fall-ploughing; for in this way many of the cells containing pupæ or young adults would be broken.

The Eyed Elater, *Alaus oculatus* (A′laus oc-u-la′tus).—Although most of our click-beetles are of moderate size, we have a few species that are large. The most common of these is the Eyed Elater (El′a-ter). This is the great pepper-and-salt-colored fellow that has two large, black, velvety, eye-like spots on the prothorax (Fig. 660). These are not its eyes, however. The true eyes are situated one on each side of the head near the base of the antenna. This insect varies greatly in size, some individuals being not more than half as large as others. The larger larvæ are about two and a half inches long, and nearly four tenths of an inch wide across the middie of the body. They live upon decaylng wood, and are often found in the trunks of old apple-trees.

FIG. 660.

There is an Elater quite similar to the preceding that

differs in having the eye-like spots less distinctly marked, and is not as common. This is *Alaus myops* (A. my'ops).

The family THROSCIDÆ (Thros'ci-dæ) includes a few small species which resemble the Elaters and Buprestids in having the prosternum prolonged behind into a process, which is received in the mesosternum. They differ from the Elaters in having the prothorax firmly joined to the mesothorax, and the front coxal cavities closed behind by the mesosternum instead of by the prosternum; and from the Buprestids in having the ventral abdominal segments all free. The adult beetles are found on flowers.

Family BUPRESTIDÆ (Bu-pres'ti-dæ).

The Metallic Wood-borers or Buprestids (Bu-pres'tids).

The Buprestids resemble the click-beetles somewhat in form, being rather long and narrow; but they are easily recognized by their metallic coloring. Their bodies are hard and inflexible, and usually appear as if made of bronze; but some species exhibit the brightest of metallic colors. The antennæ are serrate; the first and second abdominal segments are grown together on the ventral side; and these beetles do not have the power of springing when placed on the back.

The adults are found upon flowers and upon the bark of trees, basking in the hot sunshine. Some of them fly very rapidly, with a loud buzzing noise; and some drop to the ground when disturbed, and feign death.

Most of the larvæ are borers, feeding beneath bark or within solid wood. In such species the body is of a very characteristic form, which is commonly designated as "flat-headed." The flattened portion, however, is composed largely of the segments immediately following the head. The first thoracic segment is very wide and flat; the next two or three segments are also flattened, but are successively smaller; while the rest of the body is quite narrow and cylindrical. These "flat-headed" larvæ are legless, and

have been compared to tadpoles on account of their form. Their burrows are flattened, corresponding with the shape of the larger part of the body. In some of the smaller species the larvæ are cylindrical, and are furnished with three pairs of legs. These are leaf-miners; and in the adult state the body is much shorter than in the more typical species.

The Virginian Buprestid, *Chalcophora virginica* (Chal-coph′o-ra vir-gin′i-ca).—This is the largest of our common Buprestids (Fig. 661). It is copper-colored, often almost black, and has its upper surface roughened by irregular, lengthwise furrows. This beetle appears late in spring in the vicinity of pine-trees. The larvæ bore in the wood of pine, and are often very injurious.

Fig. 661.

The *Dicerca divaricata* (Di-cer′ca di-var-i-ca′ta) is three quarters of an inch or more in length, copper-colored or brassy above, with the wing-covers marked with square, elevated, black spots. The wing-covers taper very much behind, and are separated at the tips (Fig. 662). The larva bores in peach, cherry, beech, and maple.

Fig. 662.

The Flat-headed Apple-tree Borer, *Chrysobothris femorata* (Chrys-o-both′ris fem-o-ra′ta).—This is one of the most injurious of all Buprestids. The adult (Fig. 663) is about half an inch long, and is a very dark green above, with bronze reflections, especially in the furrows of the wing-covers. It appears during June and July, and lays its eggs upon the trunk and limbs of apple, peach, oak, and other trees. The larvæ at first bore into the bark and sap-wood, and later into the solid wood. The transformations are completed in one year.

Fig. 663.

To prevent the ravages of this pest, the trees are rubbed with soap during June or July, or cakes of soap are placed in the forks of the trees, so that the rains will dissolve the soap and wash it down over the trunks. This is supposed to

prevent the beetles from depositing their eggs on the trees. After a tree is once infested, the larvæ should be cut out with a gouge or a knife. Nursery stock that is infested should be promptly burned.

The Red-necked Agrilus, *Agrilus ruficollis* (Ag'ri-lus ruf-i-col'lis).—This beetle (Fig. 664) is about three tenths of an inch long. Its body is narrow and nearly cylindrical. The head is of a dark-bronze color, the prothorax of a beautiful coppery bronze, and the wing covers black. The larva bores in the stems of raspberry and blackberry, causing a large swelling, known as the Raspberry Gouty-gall. These galls should be collected and burned in early spring.

Fig. 664.

Family Lampyridæ (Lam-pyr'i-dæ).

The Firefly Family or Lampyrids (*Lam-py'rids*).

During some warm, moist evening early in our Northern June we are startled to see here and there a tiny meteor shoot out of the darkness near at hand, and we suddenly realize that summer is close upon us, heralded by her mysterious messengers, the fireflies. A week or two later these little torch-bearers appear in full force, and the gloom that overhangs marshes and wet meadows, the dusk that shrouds the banks of streams and ponds, the darkness that haunts the borders of forests, are illumined with myriads of flashes as these silent, winged hosts move hither and thither under the cover of the night.

The fireflies are soft-bodied beetles of medium or small size, with slender, usually eleven-jointed, saw-like antennæ. The prothorax is expanded into a thin projecting margin, which in most cases completely covers the head (Fig. 665). The wing-covers are rather soft, and never strongly embrace the sides of the abdomen, as with most other beetles.

Fig. 665.

Most members of this family are nocturnal insects, and

are sluggish by day. On the other hand, a few species are very active in the brightest sunshine.

The most common of these day-fliers are the soldier-beetles, *Chauliognathus* (Chaul-i-og'na-thus). These are very abundant in late summer and autumn on various flowers, but especially on those of the goldenrod. There are two very common species: the Pennsylvania Soldier-beetle, *Chauliognathus pennsylvanicus* (C. penn-syl-van'i-cus), which is yellow, with a black spot in the middle of the prothorax and one near the tip of each wing-cover (Fig. 666); and the Margined

Fig. 666.

Fig. 667.

Fig. 668.

Soldier-beetle, *C. marginatus* (C. mar-gi-na'tus). This species (Fig. 667) may be distinguished from the former by the head and lower part of the thighs being orange. The beetles of this genus are remarkable for having an extensible, fleshy filament attached to each maxilla. These filaments are probably used in collecting pollen and nectar from flowers.

Another common diurnal Lampyrid is *Calopteron reticulatum* (Ca-lop'te-ron re-tic-u-la'tum) (Fig. 668). This species represents a group in which the wing-covers are covered with a network of fine elevated lines. These insects are found on the leaves of plants, where they seek and feed upon other insects.

The true Fireflies are nocturnal, and are furnished with a light-giving apparatus, which is situated on the lower side of the abdomen; the exact position of these organs differs in different genera. Figure 665 represents a common species.

The family MALACHIIDÆ (Mal-a-chi'i-dæ) is composed chiefly of small or very small beetles, found on flowers, and on the ground near water. They vary greatly in form; but bear a general resemblance in structure to the preceding family, from which they can be distinguished by the presence of only six ventral abdominal segments. Some members of the family are furnished with soft, orange-colored vesicles which they protrude from the sides of the body, and which are supposed to be scent organs for defence. One of our most common representatives is *Collops quadrimaculatus* (Col'lops quad-ri-mac-u-la'tus), which is yellowish orange, with the top of the head and four spots on the wing-covers bluish black (Fig. 670).

FIG. 670.

Family CLERIDÆ (Cler'i-dæ.)

The Checkered Beetles.

The family Cleridæ includes a considerable number of species which are found on flowers and on the trunks of trees. Many of them are beautifully marked with strongly contrasting colors; this has suggested the common name checkered beetles for them. Frequently they are more or less ant-like in form, the prothorax being in these cases narrower than the wing-covers, and slightly narrower than the head. The abdomen has either five or six ventral segments; the anterior coxæ are conical, prominent, and contiguous, or very slightly separate; the hind coxæ are transverse, not prominent, and covered by the femora in repose; the legs are slender; and the tarsi are five-jointed.

In the larval state these insects are usually carnivorous, living under bark and in the burrows of wood-boring insects, upon which they prey; some are found in the nests of bees; and still others feed on dead animal matter.

Figure 671 represents one of our more common species, *Trichodes nuttalli* (Tri-cho'des nut-tal'li).

The family PTINIDÆ (Ptin'i-dæ) or the Death-watch Family is composed of small insects, which rarely exceed a quarter of an inch in length, and very many of them are not half that length. They are usually of a cinnamon-brown color, but not always so. The most distinctive structural feature is the position of the trochanters, which are situated between the femora and coxæ, instead of at one side of the base of the femur in each case. These insects usually live upon dead vegetable matter, and frequently upon that which has begun to decay; but some bore into solid wood, and others attack living plants. One of the latter is the Apple-twig Borer, *Amphicerus bicaudatus* (Am-phic'e-rus bi-cau-da'tus), which often injuriously affects the twigs of apple-trees; the adult beetle is about three tenths of an inch long, and the male has two thorn-like projections from the ends of the wing-covers. The Cigarette Beetle, *Lasioderma serricorne* (Las-i-o-der'ma ser-ri-cor'ne) is a serious pest in tobacco manufactories, infesting the dried tobacco-leaves and the manufactured products. *Sitodrepa panicea* (Si-tod're-pa pa-nic'e-a) is a cosmopolitan species, which feeds on many kinds of dead organic matter, both animal and vegetable. It sometimes assumes the rôle of a bookworm. We have bred it in large numbers from the cover of a very old book, a copy of Dante's Divine Comedy printed in 1536. It seems that old books are much more subject to the attacks of bookworms than others.

FIG. 671.

The family CUPESIDÆ (Cu-pes'i-dæ) includes only four American species. These are found under the bark of decaying trees, and sometimes in houses. The body is covered with small scales; other characteristics are given in the table of families.

The family LYMEXYLIDÆ (Lym-ex-yl'i-dæ) is also a very small family. It is represented in this country by only three species. Its chief interest lies in the fact that it includes the Ship-timber beetle, *Lymexylon navale* (Ly-mex'y-lon na-va'le) of Europe.

The family CIIDÆ (Ci'i-dæ) includes a small number of very small beetles, found under the bark of trees and in the dry and woody species of fungus. The body is cylindrical; the prothorax is prolonged over the head; the abdomen has five ventral segments, of which the first is longer than the others; and the tarsi are all four-jointed.

The family SPHINDIDÆ (Sphin'di-dæ) is represented in North America by only three small species, which are found in dry fungi, which grow on the trunks of trees. Although the antennæ are clubbed, and these beetles are commonly regarded as belonging to the Clavicornia, the tarsi are like those of the Heteromera, the fore and middle tarsi being five-jointed and the hind tarsi four-jointed.

Family LUCANIDÆ (Lu-can'i-dæ).

The Stag-beetles.

The stag-beetles are so called on account of their large mandibles, which in the males of some species are branched like the antlers of a stag. But they are more surely distinguished by the form of the antennæ, which are lamellate; but the plates composing the club are not capable of close apposition, and usually are not flattened. The student should carefully distinguish between this type of antenna and that of the Scarabæidæ, where the terminal segments are greatly flattened and can be brought close together so as to form a compact club.

The adult beetles are found on the trunks of trees, and are said, by Harris, to live upon sap, for procuring which the brushes of their jaws and lips seem to be designed; but it seems probable that some species at least feed upon decomposing wood. They lay their eggs in crevices of the bark of trees, especially near the roots. The larvæ that hatch from these eggs resemble the well-known larvæ of May-beetles in form. But, unlike the white grubs which feed on the roots of herbaceous plants, the larvæ of stag-beetles bore into the solid wood of the trunks and roots of trees, and reduce it to

a substance resembling very coarse sawdust. They mature slowly; it is said that the larvæ of some of the larger species require six years to complete their growth.

The family is a small one; only fourteen North American species are at present known.

The Common Stag-beetle, *Lucanus dama* (Lu-ca′nus da′-ma).—The most common of our Stag-beetles is this species (Fig. 672). It flies by night with a loud buzzing sound, and is often attracted to lights in houses. The larva is a large whitish grub resembling the larvæ of the Lamellicorn Beetles. It is found in the trunks and roots of old, partially decayed trees, especially apple, cherry, willow, and oak. The specimen figured here is a male; in the female the mandibles are shorter.

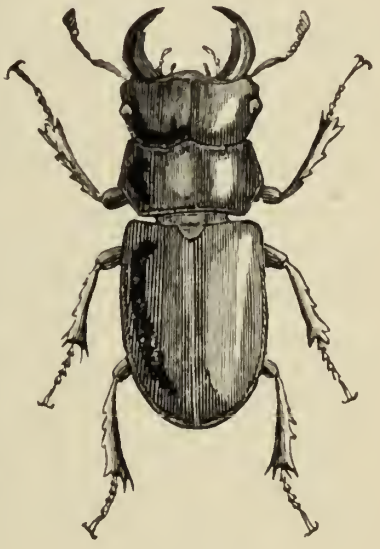

Fig. 672.

The Giant Stag-beetle, *Lucanus elaphus* (L. el′a-phus), is a large species found in the South. It measures from one and one-half inches to two inches in length, not including the mandibles, which in the case of the male are more than half as long as the body, and branched like the antlers of a stag.

The Antelope Beetle, *Dorcus parallelus* (Dor′cus par-al-le′lus). — This beetle is somewhat smaller than the species of Lucanus, and differs in having the wing-covers marked with longitudinal striæ and the teeth on the outside of the fore tibiæ much smaller (Fig. 673.)

Fig. 673.

Several species of stag-beetles that are much smaller than Dorcus are found in this country.

Fig. 674.

The Horned Passalus, *Passalus cornutus* (Pas'sa-lus cornu'tus), differs greatly in appearance from our other stag-beetles (Fig. 674). It is a large shining, black beetle, with a short horn, bent forwards, on the top of the head. This beetle and its larva are found in decaying wood. The larva is remarkable for possessing only four well-developed legs.

Family SCARABÆIDÆ (Scar-a-bæ'i-dæ).

The Scarabæids (Scar-a-bæ'ids) or the Lamellicorn (La-mel'li-corn) Beetles.

This is a very large family, including beetles that represent a wide range of variation in size, form, and habits. They are mostly short, stout-bodied beetles, of which the well-known June-bugs or May-beetles represent the most familiar type. The most useful character for distinguishing these insects is the lamellate form of the club of the antennæ, the segments constituting it being greatly flattened, and capable of being brought close together. It is this character that suggests the name lamellicorn beetles.

According to their habits, the members of this family can be separated into two well-marked groups—the scavengers and the leaf-chafers.

THE LAMELLICORN SCAVENGERS.

The lamellicorn scavengers in both the larval and adult states feed upon decaying animal and vegetable matter. Nearly all the species live in the dung of animals, chiefly that of horses and cows. But the members of one genus, *Trox*, feed upon decaying animal matter, and a few species feed upon fungi. The following are the most common representatives of this division :

I. *The Tumble-bugs.*—These are the most familiar of all dung-beetles, for their peculiar habits have attracted much attention from the earliest times. They are of rounded form, and the wing-covers are shortened so as to expose the tip

of the abdomen. They are generally black, but some are colored with rich metallic hues. They vary greatly in size.

The name tumble-bug refers to the habit which many species exhibit of forming round balls of dung, which they roll long distances. They work in pairs, a male and a female working together; and often the ball is several times as large as their combined size. They finally bury the ball in the ground, and the female deposits an egg in one side of it; this partially decomposed matter serves as food for the larva when it hatches. It should be noted that this is one of the instances, rare among insects, where the male realizes that he has some responsibility as a father, and assists the female in providing for the young.

This strange habit of rolling these balls has occasioned much speculation as to its object, and has been the source of many superstitions, especially in ancient times. The only reasonable theory that we have met is that as many predaceous insects frequent the masses of dung from which the balls are obtained, in order to prey upon the larvæ which live there, the more intelligent tumble-bugs remove the food for their larvæ to a safe distance.

The most noted member of this group of genera is the Sacred Beetle of the Egyptians, *Ateuchus sacer* (A-teu'chus sa'cer). This insect was held in high veneration by this ancient people. It was placed by them in the tombs with their dead; its picture was painted on sarcophagi, and its image was carved in stone and precious gems. These sculptured beetles can be found in almost any collection of Egyptian antiquities.

From the habits and structure of this Scarabæid the Egyptians evolved a remarkable symbolism. The ball, which the beetles were supposed to roll from sunrise to sunset, represented the earth; the beetle itself personified the sun, because of the sharp projections on its head, which extend out like rays of light; while the thirty segments of its six tarsi represented the days of the month. All indi-

viduals of this species were thought to be males, and a race of males symbolized a race of warriors. This latter superstition was carried over to Rome, and the Roman soldiers wore images of the Sacred Beetle set in rings.

Our common tumble-bugs are distributed among three genera: *Canthon*, *Copris*, and *Phanæus*. In the genus *Canthon* (Can'thon) the middle and posterior tibiæ are slender, and scarcely enlarged at the extremity. *Canthon lævis* (C. læ'vis) is our most common species (Fig. 675). In *Copris* (Co'pris) and *Phanæus* (Pha-næ'us) the middle and posterior tibiæ are dilated at the extremity. In *Phanæus* the fore tarsi are wanting, and the others are not furnished with claws; the species are brilliantly colored. *Phanæus carnifex* (P. car'ni-fex), with its rough copper-colored thorax and green elytra, is one of our most beautiful beetles, and is our best-known species. It is about two thirds inch in length, and the head of the male is furnished with a prominent horn. In *Copris* all the tarsi are present and furnished with claws. *Copris carolina* is a large well-known species, which measures more than one inch in length.

FIG. 675.

II. *The Aphodian* (A-pho'di-an) *Dung-beetles.*—These are small insects, our common species measuring from one sixth to one third inch in length. The body is oblong, convex, or cylindrical in form, and, except in one small genus, the clypeus is expanded so as to cover the mouth-parts entirely. These insects are very abundant in pastures in the dung of horses and cattle, and immense numbers of them are often seen flying through the air during warm autumn afternoons. More than one hundred North American species have been described; of these seventy belong to the genus *Aphodius* (A-pho'di-us). One of the more common species is *Aphodius fimetarius* (A. fim-e-ta'ri-us), which is about one third inch in length, and is easily recognized by its red wing-covers.

III. *The Earth-boring Dung-beetles.*—These beetles are of a rounded convex form (Fig. 676). They differ from all other dung-beetles in having the antennæ eleven-jointed, and in the labrum and mandibles being visible from above. This is a small group, less than twenty North American species having been described. The popular name is derived from that of the typical genus, *Geotrupes* (Ge-o-tru'pes), which signifies earth-boring. Those species the habits of which are known live in excrement. The females bore holes into the earth either beneath the dung or near it; into these holes they convey a quantity of the dung: this is to serve as food for the larvæ, an egg being laid in each hole. This is an approach to the peculiar habits of the tumble-bugs.

Fig. 676.

IV. *The Skin-beetles.*—The members of this group are oblong, convex species, in which the surface of the body and wing-covers is usually very rough, and covered with a crust of dirt, which is removed with great difficulty. They are small or of medium size; our most common species measure from one third to one half inch in length. The abdomen is covered by the elytra; the feet are hardly fitted for digging, but the femora of the front legs are greatly dilated. Our species all belong to the genus *Trox* (Fig. 677). They feed upon dried, decomposing animal matter; many species are found about the refuse of tanneries, and upon the hoofs and hair of decaying animals.

Fig. 677.

THE LAMELLICORN LEAF-CHAFERS.

The leaf-chafers are herbivorous insects which in the adult state usually feed upon the leaves of trees, but many of the species devour the pollen and petals of flowers. In the larval state some of these insects are found in rotten wood; others live in the ground, where they feed upon the roots of grass and other plants. These larvæ are thick,

fleshy grubs, with well-developed legs (Fig. 678). The caudal segments of the abdomen are very large, and appear black on account of the large amount of dirt in the intestine. The body is strongly curved, so that the larvæ can crawl only with great difficulty; when in the ground they usually lie on their backs.

FIG. 678.

The following groups include the more important representatives of this division :—

I. *The May-beetles or June-bugs.*— During the warm evenings of May and June we throw open our windows so that we may feel the refreshing coolness of the night air and the inspiration of the new summer. Suddenly, as we sit working or reading, our peace is disturbed by a buzzing object which whirls above us. Then comes a sharp thud and silence. A little later the scratching of six pairs of tiny claws tells us the whereabouts of the intruder. But so familiar are we with his kind that we need not look to know how he appears, the mahogany-brown blunderer, with yellowish wings sticking out untidily from under his polished wing-covers.

Although these insects are beetles, and attract our attention each year in May, they have received the infelicitous title of June-bugs. They are more properly termed May-beetles.

The May-beetles belong to the genus *Lachnosterna* (Lach-no-ster'na), of which we have more than sixty species. The adults frequently do much injury by eating the foliage of trees. In the case of large trees this injury usually passes unnoticed; but small trees are often completely defoliated by them. When troublesome, they can be easily gathered by shaking them from trees upon sheets. Figure 679 represents a common species.

FIG. 679.

The larvæ of the different species of May-beetles are commonly classed together under the name "white grubs." They are often great pests in meadows and in cultivated fields. We have known large strawberry plantations to be destroyed by them, and have seen large patches of ground in pastures from which the dead sod could be rolled as one would roll a carpet from a floor, the roots having been all destroyed and the ground just beneath the surface finely pulverized by these larvæ. No satisfactory method of fighting this pest has been discovered as yet. If swine be turned into fields infested by white grubs they will root them up and feed upon them. We have destroyed great numbers of the beetles by the use of trap-lanterns, but many beneficial insects were destroyed at the same time.

II. *The Rose-bugs.*—The common rose-bug, *Macrodactylus subspinosus* (Mac-ro-dac'ty-lus sub-spi-no'sus), is a well-known pest. It is a slender beetle, tapering before and behind, and measuring three eighths inch in length (Fig. 680). It is thickly clothed with fine, yellow, scale-like hairs, which give it a yellow color; the legs are long, slender, and of a pale-red color. These beetles appear in early summer, and often do great injury to roses and other flowers, and to the foliage of various fruit-trees and shrubs. This is a very difficult pest to control. The best method now known is to use Paris-green when safe to do so; in other cases the beetles should be collected by jarring them into a large funnel which is fitted into a can. The larvæ of rose-bugs feed on the roots of plants.

FIG. 680.

III. *The Shining Leaf-chafers.*—These insects resemble the May-beetles in form, but can be distinguished from them by the position of the hinder pair of spiracles, which are visible on the sides below the edges of the wing-covers; and they differ from the other leaf-chafers in which the spiracles are in this position in that the tarsal claws are of unequal size, one claw of each pair being larger than the other.

These beetles are usually polished, and many of them are of brilliant colors. To this family belong the most beautiful beetles known, many appearing as if made of burnished gold or silver, or other metal.

The Goldsmith-beetle, *Cotalpa lanigera* (Co-tal'pa la-nig'e-ra).—This is one of our most beautiful species. It measures a little less than one inch in length, and is a broad oval in shape. It is of a lemon-yellow color above, glittering like burnished gold on the top of the head and thorax; the under side of the body is copper-colored and thickly covered with whitish wool.

The Spotted Pelidnota, *Pelidnota punctata* (Pel-id-no'ta punc-ta'ta).—This beetle is reddish brown above, with three black spots on each wing-cover and one on each side of the prothorax (Fig. 681). The scutellum, base of the head, and the entire body beneath are of a deep bronzed-green color. The adult is commonly found feeding on the leaves of grape. The larva feeds upon decaying roots and stumps of various trees.

FIG. 681.

The Light-loving Anomala, *Anomala lucicola* (A-nom'a-la lu-cic'o-la).—This also feeds on the leaves of grape. It resembles the preceding species in form, but is much smaller, measuring only about one third inch in length. It is of a pale dull yellow color; the prothorax is black, margined with dull yellow, and the hinder part of the head and the ventral side of the body are also black; sometimes the abdomen is brown. As this beetle appears early in the summer, it can be safely destroyed with Paris-green, for the subsequent rains will wash the poison from the vines before the fruit ripens.

IV. *The Rhinoceros-beetles.*—The name rhinoceros-beetles was suggested for this group by the fact that in many species the male bears a horn on the middle of the head. In addition to this horn there may be one or more horns on the

thorax. These beetles are of medium or large size; in fact, the largest beetles known belong to this group. As with the flower-beetles, the claws of the tarsi are of equal size, but the fore coxæ are transverse, and not prominent.

One of the largest of our rhinoceros-beetles is *Dynastes tityrus* (Dy-nas'tes tit'y-rus). This is of a greenish-gray color, with scattered black spots on the wing-covers, or, if only recently transformed, of a uniform dark brown. The

FIG. 682.

male (Fig. 682) bears a prominent horn on the top of his head, and a large one and two small ones on his prothorax. The female has only a tubercle on the head. This insect is found in the Southern States; the larva lives in rotten wood. In the far West there is a closely allied species, *Dynastes grantii* (D. gran'ti-i), in which the large horn on the thorax is twice as long as in *D. tityrus*. In the West Indies there occurs a species, *Dynastes hercules* (D. her'cu-les), which measures six inches in length.

Several other genera occur in this country, in some of which the males have prominent horns; in others the horns are represented by tubercles, or are wanting. The following species represents the latter type.

The Sugar-cane Beetle, *Ligyrus rugiceps* (Lig'y-rus ru'gi-ceps).—This beetle is a serious pest in the cane-fields of Louisiana, and it sometimes injures corn. Figure 683 represents the adult, and its method of attacking a plant.

V. *The Flower-beetles.*—The flower-beetles are so called because many of them are often seen feeding upon pollen and flying from flower to flower. These beetles are somewhat flattened, or nearly level on the back; the claws

FIG. 683.--The Sugar-cane Beetle.

of the tarsi are of equal size, and the fore coxæ are conical and prominent. Nearly sixty species occur in this country.

The Hermit Flower-beetle, *Osmoderma eremicola* (Os-mo-der′ma er-e-mic′o-la).—This is one of the larger of our Flower-beetles (Fig. 684). It is of a deep mahogany-brown color, nearly smooth, and highly polished. It is supposed that the larva lives on decaying wood in forest-trees.

Fig. 684.

The Rough Flower-beetle, *Osmoderma scabra* (O. sca′bra), is closely allied to the preceding. It is not quite as large, measuring about one inch in length. It is purplish black, and the wing-covers are roughened with irregular, coarsely-punctured striæ. It is nocturnal, concealing itself during the day in the crevices and hollows of trees. The larva lives in the decaying wood of apple and cherry, consuming the wood and inducing more rapid decay.

The Bumble Flower-beetle, *Euphoria inda* (Eu-pho′ri-a in′da).—The most common of our Flower-beetles, at least in the North, is a yellowish-brown one, with the wing-covers sprinkled all over with small, irregular black spots (Fig. 685). It is one of the first insects to appear in the spring. It flies near the surface of the ground with a loud humming sound, like that of a bumble-bee, for which it is often mistaken. During the summer months it is not seen; but a new brood appears about the middle of September. The adult is a general feeder occurring upon flowers, eating the pollen; upon corn-stalks and green corn in the milk, sucking the juices; and upon peaches, grapes, and apples. Occasionally the ravages are very serious.

Fig. 685.

The genus *Euphoria* represents well the form of the more typical Flower-beetles, which are distinguished by the margin of each wing-cover having a large wavy indentation near its base, which renders the side pieces of the meso-

thorax visible from above. This indentation makes it unnecessary for these insects to raise or expand their wing-covers when flying, as most beetles do, as they are able to pass the wings out from the sides.

The Sad Flower-beetle, *Euphoria melancholica* (Eu-pho'-ri-a mel-an-chol'i-ca).—This is a much smaller species than the Bumble Flower-beetle, measuring hardly half an inch in length. It is almost black, with irregular transverse white lines on the wing-covers. We have received several reports of its producing injuries similar to those of *E. inda*.

The Fig-eater, *Allorhina nitida* (Al-lo-rhi'na nit'i-da).—This species extends over the Atlantic slope, and is very common in the South. It is a green, velvety insect, measuring from two thirds of an inch to one inch in length. It is somewhat pointed in front, and usually has the sides of the thorax and elytra brownish yellow. These beetles often fly in great numbers at night, making a loud buzzing noise similar to that of the May-beetles. In fact, in the South the term June-bug is often applied to this insect. The larvæ feed upon the roots of grass and other plants. Sometimes they leave the ground and crawl from one place to another. When they do so they, strangely enough, crawl upon their backs, making no use of their short legs. On one occasion we saw them crawling over the pavements on the Capitol grounds at Washington in such numbers that bushels of them were swept up and carted away.

The family SPONDYLIDÆ (Spon-dyl'i-dæ), or aberrant long-horned beetles, includes only four North American

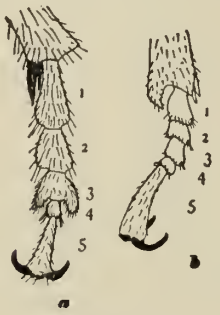

FIG. 686.

FIG. 687.

FIG. 688.

species. These live under the bark of pine-trees. They are closely allied to the Cerambycidæ, but differ in the form of the tarsi and in the structure of the antennæ. The fourth segment of the tarsus, although much reduced in size, is distinctly visible; the first three segments are but slightly dilated, and the third is either bilobed or not (Fig. 686). The segments of the antennæ have deep impressions, in which are situated the organs of special sense (Fig. 687). The most common species is *Parandra brunnea* (Pa-ran'dra brun'ne-a) (Fig. 688); this insect is of a mahogany-brown color.

Family CERAMBYCIDÆ (Cer-am-byc'i-dæ).

The Long-horned Beetles or Cerambycids (*Ce-ram'by-cids*).

This is a very large family, there being about six hundred described species in North America alone. As a rule the beetles are of medium or large size, and graceful in form; many species are beautiful in color. The body is oblong, often cylindrical. The antennæ are long, often longer than the whole body; but except in one genus, *Prionus*, they are only eleven-jointed, as with most beetles. The legs are also long, and the tarsi are apparently four-jointed, the fourth segment being very small and hidden; the third segment of the tarsi is strongly bilobed (Fig. 689).

FIG. 689.

They are strong fliers and swift runners; but many of them have the habit of remaining motionless on the limbs of trees for long intervals, and when in this apparent trance they suffer themselves to be picked up. But, when once caught, many species make an indignant squeaking by rubbing the prothorax and mesothorax together.

FIG. 690.

The larvæ are borers, living within the solid parts of trees or shrubs, or beneath bark. They are white or yellowish grubs. The body is soft, and tapers slightly from head to tail (Fig. 690); the jaws are powerful, enabling these insects to bore into the

hardest wood. The larval state usually lasts two or three years. The pupa state is passed within the burrow made by the larva; frequently a chamber is made by partitioning off a section of the burrow with a plug of chips; but sometimes the larva builds a ring of chips around itself just beneath the bark before changing to a pupa. The pupal state is comparatively short, lasting only a few days or weeks.

This family comprises three subfamilies, which are separated by Le Conte and Horn as follows:—

A. Sides of the prothorax with a sharp margin. p. 568. PRIONINÆ.

AA. Prothorax not margined.

B. Front tibiæ not grooved; palpi never acute at tip. p. 569. CERAMBYCINÆ.

BB. Front tibiæ obliquely grooved on the inner side; palpi with the last segment cylindrical and pointed. p. 572..... LAMIINÆ.

Subfamily PRIONINÆ (Pri-o-ni'næ).

The Prionids (Pri-o'nids).

The larger of the Long-horned Beetles constitute this subfamily. They are distinguished from other Cerambycids by having the sides of the prothorax prolonged outwards into a thin margin, which is more or less toothed. The wing-covers are usually leathery in appearance, and of a brownish or black color. The following are our best-known species:—

FIG. 691.

The Broad-necked Prionus, *Prionus laticollis* (Pri-o'nus lat-i-col'-lis).—This is the largest of our common species; but the individuals vary from less than one inch to two inches in length. It is of a pitchy-black color, and of the form shown in Figure 691. The antennæ are twelve-jointed in both sexes. The larva

is a large fleshy grub, and infests the roots of grape, apple, poplar, and other trees.

The Tile-horned Prionus, *Prionus imbricornis* (P. im-bri-cor′nis), is very similar to the preceding species, but can be distinguished at a glance by the form of the antennæ. In the antennæ of the male the number of the segments varies from eighteen to twenty, while in the female the number varies from sixteen to seventeen. The popular name refers to the fact that the segments of the antennæ of the male overlap one another like the tiles on a roof. The larva infests the roots of grape and pear, and also feeds upon the roots of herbaceous plants.

The Straight-bodied Prionid, *Orthosoma brunneum* (Or-tho-so′ma brun′ne-um), is also a common species. The body is long, narrow, and somewhat flattened; it measures one inch to one and one-half inches in length, and is of a light-brown color. The prothorax is short, and is armed on each side with three sharp spines. The sides of the wing-covers are very nearly parallel; this suggests the common name. The adult flies by night, and is often attracted to lights; the larva is supposed to infest pine.

Subfamily CERAMBYCINÆ (Ce-ram-by-ci′næ).

The Typical Cerambycids (*Ce-ram′by-cids.*)

In this subfamily the prothorax is rounded on the sides, the the tibiæ of the fore legs are not grooved, and the palpi are never acute at tip. There are nearly four hundred American species, representing more than one hundred genera. The few species mentioned below are those that the beginning student is most likely to meet.

FIG. 692.

The Ribbed Pine-borer, *Rhagium lineatum* (Rha′gi-um lin-e-a′tum).—This is a gray beetle mottled with black, and has a narrow thorax, with a spine on each side (Fig. 692). It received its name because of the three ridges extending lengthwise on each

wing-cover. Its larva bores in the wood of pine-trees. On one occasion the writer found many of them in a pine-tree eight inches in diameter, which they had bored through and through. When the larva is full grown it makes a hole nearly through the thick bark of the tree, so that it may easily push its way out after its transformations; it then retreats a short distance, and makes a little ring of chips around itself, between the bark and the wood, and changes to a pupa within this rude cocoon. The adult beetle remains in this pupal cell through the winter.

The Cloaked Knotty-horn, *Desmocerus palliatus* (Desmoc'e-rus pal-li-a'tus).—This beautiful insect is of a dark-blue color, with greenish reflections. The basal part of the wing-covers is orange-yellow, giving the insect the appearance of having a yellow cape thrown over its shoulders (Fig. 693). The segments in the middle of the antennæ are thickened at the outer end, so that they look like a series of knots. The adult is found quite common in June and July on elder, in the pith of which the larva bores.

Fig. 693.

The Beautiful Maple-borer, *Plaginotus speciosus* (Plag-i-no'tus spe-ci-o'sus).—This is a very handsome insect, marked with black and yellow, as indicated in Figure 694. It lays its eggs in midsummer on the trunks of sugar-maples, in the wood of which the larvæ bore. If an infested tree be examined in the spring the presence of these borers can be detected by the dust that falls from the burrows. The larvæ can be destroyed at this time by the use of a knife and a stiff wire.

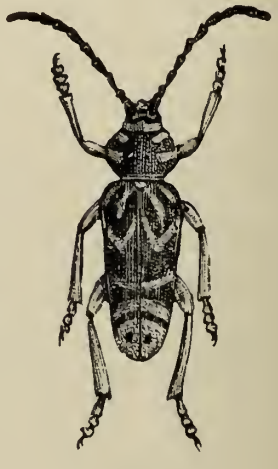

Fig. 694.

The Locust-borer, *Cyllene robiniæ* (Cyl-le'ne ro-bin'i-æ).—To the enthusiastic en-

tomologist the goldenrod is a rich mine, yielding to the collector more treasures than any other flower. It gives up its gold-dust pollen to every insect-seeker; and because of this generous attitude to all-comers it is truly emblematic of the country that has chosen it as its national flower.

Among the insects that revel in this golden mine in the autumn is a black beetle with numerous transverse or wavy yellow bands (Fig. 695). This beetle is also found on locust-trees, where it lays its eggs. The larvæ bore under the bark and into the hard wood; they attain their growth in a little less than a year. The locust-trees have been completely destroyed in some localities by the depredations of these larvæ.

FIG. 695.

The Painted Hickory-borer, *Cyllene pictus* (C. pic'tus).—This beetle resembles the preceding so closely that the same figure will represent either. But the Hickory-borer not only infests a different kind of tree, but appears in the spring instead of the autumn. In this species the second segment of the hind tarsus is densely pubescent beneath, while it is glabrous in the Locust-borer.

The Oak-pruner, *Elaphidion villosum* (El-a-phid'i-on villo'sum).—The work of this insect is much more likely to attract attention than the insect itself. Frequently, in the autumn, the ground beneath oak-trees, and sometimes beneath apple-trees also, is strewn with small branches that have been neatly severed from the trees as if with a saw. These branches are sometimes nearly an inch in diameter, and have been cut off by the larva of a beetle, which on account of this habit is called the Oak-pruner. The beetle lays each of its eggs in a small twig. The larva eats out the inside of this twig, and works down into a larger branch, following the centre of it towards the trunk of the tree. When full grown the larva enlarges the burrow suddenly so as nearly to sever the branch from the tree, leaving only the bark and a few fibres of wood. It then retreats up its bur-

row a short distance, and builds a plug of chips below it. The autumn winds break the branch from the tree. The larva remains in its burrow through the winter, and undergoes its transformations in the spring. No one has explained its object in severing the branch. The adult is a plain, brownish-gray beetle. Whenever it becomes abundant its increase can be checked by gathering the fallen branches in the autumn and burning them before the beetles have escaped.

Subfamily LAMIINÆ (Lam-i-i′næ).

The Lamiids (*Lam′i-ids*).

As in the preceding subfamily, the prothorax is rounded with these beetles; but the Lamiids are distinguished by having the fore tibiæ obliquely grooved on the inner side, and the last segment of the palpi cylindrical and pointed. The following are some of the more important species:—

The Sawyer, *Monohammus confusor* (Mon-o-ham′mus con-fu′sor).—This beautiful brown and gray beetle is about an inch and a quarter long, with antennæ as long as the body in the case of the female and twice as long in the case of the male (Fig. 696). The larva bores in the sound wood of pine and of fir, making a hole, when full grown, one half inch in diameter. The pupa state is passed within the burrow. It sometimes occurs in such numbers as to kill the infested trees.

FIG. 696.

The Round-headed Apple-tree

Borer, *Saperda candida* (Sa-per'da can'di-da).—Excepting the Codlin-moth, which infests the fruit, this is the worst enemy of the apple that we have. Its common name is used to distinguish it from the Flat-headed Apple-tree Borer, already described, the larva of this species being nearly cylindrical in form (Fig. 690). The eggs are laid on the bark at the base of the tree late in June or July. The larva at first bores in the soft sap-wood, making a disk-shaped mine; after this it works in an upward direction in the harder wood, and at the close of its larval existence comes to the surface several inches above the place it entered. It requires nearly three years for this larva to attain its growth; it changes to a pupa, near the upper end of its burrow, about the middle of May, and emerges as a beetle in June. The beetle (Fig. 697) is of a pale-brown color above, with two

FIG. 697.

FIG. 698.

FIG. 699.

broad, white stripes extending the whole length of the body. Although the larva is found chiefly in apple, it infests many other trees.

The Two-spotted Oberea, *Oberea bimaculata* (O-ber'e-a bi-mac-u-la'ta), is sometimes a serious pest, boring in the canes of blackberry and raspberry. The larva resembles that of the preceding species. The adult (Fig. 698) is about one half inch in length and of a deep-black color, except the prothorax, which is yellow. There are usually two or three black spots on the pronotum, but frequently these are wanting.

The Red Milkweed-beetles, *Tetraopes* (Tet-ra-o′pes).—There are several species of bright-red beetles that are common on milkweeds (*Asclepias*). These belong to the genus *Tetraopes*. Our most common species (Fig. 699) is *T. tetraophthalmus* (T. tet-ra-oph-thal′mus). In this species there are four black spots on each wing-cover, and the antennæ are black, and not ringed with a lighter color. The larva bores in the roots and the lower parts of the stems of milkweeds.

Family CHRYSOMELIDÆ (Chrys-o-mel′i-dæ).

The Leaf-beetles or Chrysomelids (*Chrys-o-me′lids*).

The Leaf-beetles are so called because they feed upon the leaves of plants both as larvæ and adults. They are usually short-bodied, and more or less oval in outline; the antennæ are usually of moderate length; and the front is not prolonged into a beak. The legs are usually short, and are furnished with tarsi of the same type as those of the preceding family (see Fig. 689, p. 567).

Although we are unable to cite any characteristic that will invariably distinguish these beetles from the preceding family, the student will rarely have any difficulty in making the distinction. The beetles of the genus *Donacia*, described below, are the only common ones that are liable to be misplaced. In other cases the more or less oval form of the body, the comparatively short antennæ, and the leaf-feeding habits will serve to distinguish the Chrysomelids.

The Leaf beetles are nearly all comparatively small, the Colorado Potato-beetle being one of our larger species.

The eggs are usually elongated and yellowish, and are laid upon the leaves or stems of the plants upon which the larvæ feed. Many of the larvæ live exposed on the leaves of plants; others that live in similar situations cover themselves with their excrement; some are leaf-miners; and a

few, as the Striped Squash-beetle, bore in the roots or stems of plants.

This is a large family, of which about six hundred North American species are known. The following illustrations will serve to show the variations in form and habits:

The Long-horned Leaf-beetles, *Donacia* (Do-na'ci-a).—These are the common Leaf-beetles that are liable to be mistaken for Cerambycids. They are of elongated form, with slender antennæ (Fig. 700). They measure from a quarter to a half inch in length, and are of a metallic color—either greenish, bronze, or purplish. The lower side of the body is paler, and is clothed with very fine hair which serves as a water-proof coat when the insect is submerged. The larvæ feed upon the roots or in the stems of aquatic plants; and the adults are found on the leaves of the same plants. We have many species, but they resemble each other so closely that it is difficult to separate them.

FIG. 700.

The Three-lined Lema, *Lema trilineata* (Le'ma tri-lin-e-a'ta).—This insect is common, feeding on the leaves of potato. The beetle is a quarter of an inch long, yellow, with three black stripes on the wing-covers. The eggs are laid in small clusters on the leaves. The larvæ feed on the leaves, and can be easily recognized by a habit they have of covering their backs with their own excrement. They transform in the ground in earthen cells. There are two broods each year; the second hibernates in the ground as pupæ.

The Asparagus-beetle, *Crioceris asparagi* (Cri-oc'e-ris as-par'a-gi).—This is a small, red, yellow, and black beetle, that gnaws holes into the heads of young asparagus, and lays oval, black eggs upon them. The larvæ, which are small, brown, slug-like grubs, also feed upon the young heads in the spring, and later in the season a second brood feed upon the full-grown plant. Figure 701 represents a head of as-

paragus bearing the eggs of this beetle, also a beetle and a larva enlarged. The beetle measures about a quarter of an inch in length. Where this pest occurs care should be taken to destroy all wild asparagus. This will force the beetles to lay their eggs upon the shoots that are cut for market. The larvæ hatching from such eggs will not have a chance to mature.

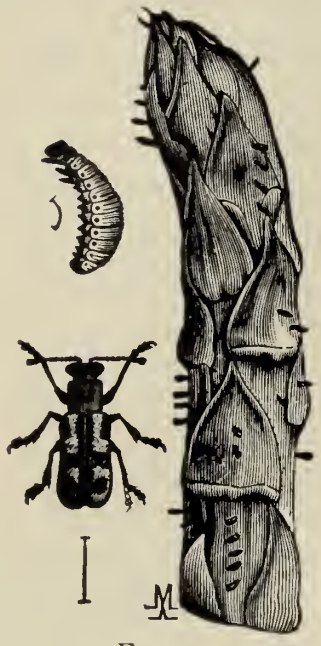

FIG. 701

The Colorado Potato-beetle, *Doryphora decemlineata* (Do-ryph'o-ra dec-em-lin-e-a'ta).—A good many insect tramps have come to us from Europe and from Australia, and appropriated whatever pleased them of our growing crops or stored grain. But two of our worst insect pests have swarmed out on us in hordes from their strongholds in the region of the Rocky Mountains. These are the Rocky Mountain Locust and the Colorado Potato-beetle (Fig. 702). The latter insect dwelt near the base of the Rocky Mountains, feeding upon the sand-burr (*Solanum rostratum*), until about the year 1859. At this time it began to be a pest in the potato-fields of the settlers in that region. Having acquired the habit of feeding upon the cultivated potato, it began its eastward march across the continent, spreading from potato patch to potato patch. At first the migration took place at about the rate of fifty miles a year, but later it was more rapid; and in 1874 the insect reached the Atlantic coast.

FIG. 702.

FIG. 703.

The Three-spotted Doryphora, *Doryphora clivicollis* (D. cliv-i-col'lis).—This resembles the Colorado potato-beetle in size and form. It is of a deep-blue color, except the wing-covers, which are orange, with three dark-blue spots on each (Fig. 703).

There is considerable variation in the size and shape of these spots; frequently the two near the base of the wing-covers are joined so as to make a continuous band extending across both wing-covers. The larva feeds on milkweed (*Asclepias*).

The Diabroticas.—Several very important pests belong to the genus *Diabrotica* (Di-a-brot'i-ca). In the East they are known as cucumber-beetles; but on the Pacific coast, where they are more feared on account of their injuries to fruit and fruit-trees, they are commonly called the Diabroticas. They are chiefly greenish-yellow beetles, marked with black stripes or spots. The Striped Diabrotica, *D. vittata* (D. vit-ta'ta), has two black stripes on each wing-cover. The adult feeds on the leaves of cucumber, squash, and melon; and the larva, which is a slender, worm-like creature, bores in the stems and roots of the same plants. The Twelve-spotted Diabrotica, *D. duodecimpunctata* (D. du-od-e-cim-punc-ta'ta), and *Diabrotica soror* (D. so'ror), agree in having six black spots on each wing-cover (Plate I, Fig. 2). The former is very common in the East; the latter occurs on the Pacific coast, and is the most destructive of all of the Diabroticas. *Diabrotica longicornis* (D. lon-gi-cor'nis) is a grass-green species, which feeds on the pollen and silk of corn and on the pollen of other plants. Its larva is known as the corn root-worm; it is very destructive to corn in the Mississippi Valley. Its injuries are greatest where corn is grown on the same land year after year; hence a rotation of crops should be practised where this pest is troublesome. The other species of *Diabrotica* mentioned above are difficult to combat, as the leaves of cucumber, melon, and squash are very apt to be injured by the use of arsenical poisons. The most practicable way of protecting these vines is to cover them while young with frames covered with netting. Where they infest fruit-trees they can be fought with Paris-green; but this poison must be used with great care on such trees as prune and apricot. Squashes

should not be grown in orchards, as is sometimes done in California.

The Flea-beetles.—There is a group of leaf-beetles, of which we have many species, in which the hind legs are fitted for leaping, the thighs being very large. These are commonly called the flea-beetles.

The Striped Flea-beetle, *Phyllotreta vittata* (Phyl-lo-tre'ta vit-ta'ta), is exceedingly common on cabbage, turnip, radish, mustard, and allied plants. It is a small, black, shining beetle, with a broad, wavy, pale, dull-yellow stripe upon each wing-cover (Fig. 704); it measures about one tenth of an inch in length. These beetles eat numerous little pits in the thicker leaves that they infest, and minute perforations in the thinner-leaved plants. The larva is a slender, white worm, about one third inch in length; it feeds on the roots of the plants infested by the adult. The adult beetles can be destroyed with kerosene emulsion.

FIG. 704.

The Cucumber Flea-beetle, *Crepidodera cucumeris* (Crep-i-dod'e-ra cu-cum'e-ris), is a common pest of melon and cucumber vines; it also attacks the leaves of potato, raspberry, turnip, cabbage, and other plants. This is a minute black species, measuring less than one twelfth of an inch in length. The body is finely punctured, and clothed with a whitish pubescence; there is a deep transverse furrow across the hinder part of the prothorax; the antennæ are dull yellow, and the legs are of the same hue, except the posterior femora, which are brown. The adult beetles feed on the leaves of plants in the same manner as the preceding species; but the larva is a miner, feeding within the substance of the leaves of the infested plants.

The Steel-blue Flea-beetle, *Haltica chalybea* (Hal'ti-ca cha-lyb'e-a).—This is a larger species than the two preceding, measuring from one sixth to one fifth inch in length, and is of a dark steel-blue color. It is a great pest in vineyards, eating into the buds of grape in early spring,

and later gnawing holes into the leaves (Figs. 705 and 706). In May and June the brown, sluggish larvæ may also be found feeding upon the upper surface of the leaves. The full-grown larva is chestnut-brown, marked with black spots. The beetles can be destroyed in early spring by jarring them from the vines onto a sheet wet with kerosene; use for this purpose a piece of sheeting several yards long, with a stick fastened to each end so that it can be easily moved from vine to vine.

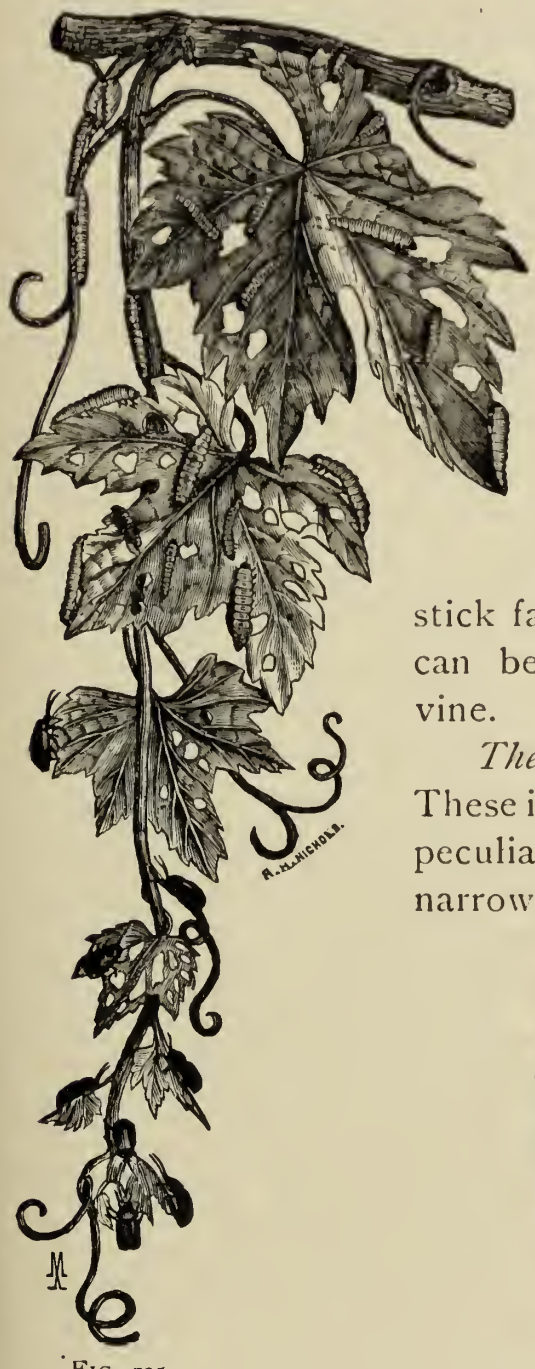

FIG. 705.

The Wedge-shaped Leaf-beetles.— These insects are characterized by the peculiar form of the body, which is narrow in front and broad behind. In

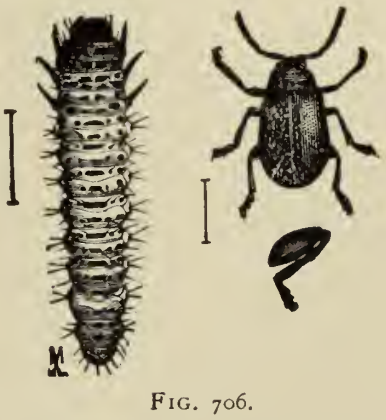

FIG. 706.

most of the species the body is much roughened by deep pits; and usually the pits on the wing covers are in regular rows. These insects and the tortoise-beetles differ from other leaf-beetles in having the fore part of the head prominent, so that the mouth is confined to the under surface. Some of the larvæ

feed externally upon leaves and bear a parasol composed of their excrement; other species are leaf-miners. *Odontota rubra* (Od-on-to'ta ru'bra) is a good representative of this group (Fig. 707). It varies in length from one eighth to one fifth of an inch. It is of a reddish color, with the elevated portions of the elytra more or less spotted with black. The larva mines in the leaves of apple, forming a blotch-mine; the transformations are undergone within the mine. We have also found this species mining the leaves of basswood in great numbers.

FIG. 707.

The Tortoise-beetles.—Among the more beautiful Coleoptera are certain bright, golden, green, or iridescent beetles found on the leaves of sweet-potato, morning-glory, nettle, and other plants. In these beetles the body is flattened below and convex above; the head is nearly or quite concealed beneath the prothorax; and the margins of the prothorax and elytra are broadly expanded, forming an approximately circular or oval outline, and suggesting a resemblance to the shell of a tortoise. Not all of the species are iridescent; and in the case of those that are, the brightness of the colors are said to depend on the emotions of the insect. What a beautiful way to express one's feelings—to be able to glow like melted gold when one is happy! Unfortunately for the beauty of our collections, these bright colors disappear after the death of the insect.

The larvæ of the tortoise-beetles are flattened, and have the margin of the body fringed with spines. At the caudal end of the body there is a forked appendage which serves a very strange purpose. This fork is bent forward over the back, and to it are attached the cast-off skins of the larva and its excrement; these constitute a parasol. When about to change to the pupa state these larvæ fasten the caudal end of the body to the under side of a leaf; the skin then splits open, and is forced back to this end of the body, where it remains.

The One-dotted or Five-dotted Tortoise, *Physonota unipunctata* (Phys-o-no′ta u-ni-punc-ta′ta).—The largest of our bright-colored tortoise-beetles is common in midsummer, feeding on the leaves of wild sunflower. It measures from three eighths to one half inch in length, and is yellow, with the margins whitish. On the prothorax there are five black dots—two close together in front, and three more widely separated behind. Sometimes all but one of these dots are wanting. It was this form that was first described, hence the name *unipunctata.* We have found the larvæ abundant in July on the same plant with the adults.

Most of our species of tortoise-beetles are of moderate size, measuring about one fourth inch or even less in length. These represent two genera, *Cassida* (Cas′si-da) and *Coptocycla* (Cop-toc′y-cla). These genera can be separated by the length of the antennæ, which extend beyond the base of the prothorax in the latter (Fig. 708), but do not in the former.

Fig. 708.

The Argus-tortoise, *Chelymorpha argus* (Chel-y-mor′pha ar′gus), is a large brick-red species, which measures from three eighths to seven sixteenths of an inch in length, and has the prothorax and wing-covers marked with many black spots. This species feeds on milkweed (*Asclepias*).

Family Bruchidæ (Bru′chi-dæ).

The Pea-weevil Family.

These are small beetles, the larvæ of which live in the seeds of leguminous plants. The head of the adult is prolonged into a broad beak; and the wing-covers are rather short, so that the tip of the abdomen is always exposed (Fig. 709).

Fig. 709.

The Pea-weevil, *Bruchus pisi* (Bru′chus pi′si).—"Buggy-peas" are well known in most sections of our country; but just how the "bugs" find their way into

the peas is not so generally understood. The eggs of the Pea-weevil are laid upon the pod while the peas are quite small; when the larvæ hatch they bore through the pod into the young peas. Here they feed upon the substance of the seed, which ripens, however, and in some cases will germinate when planted. The larva before transforming eats a circular hole on one side of the seed, leaving only a thin scale, which is easily pushed away by the mature beetle. The adult is about one fifth inch in length; it is dark brown, with a few white spots on the wing-covers, and one on the prothorax near the middle. Sometimes the beetles leave the peas during the autumn or winter; but as a rule they remain in the seed till spring, and are often planted with it. Seed peas should be placed in water, and the infested ones, which will float, should be picked out and destroyed. This species is not known to oviposit on dry peas.

This and other grain-infesting insects can be destroyed by placing the grain into a close receptacle with a small quantity of bisulphide of carbon.

The Bean-weevil, *Bruchus obtectus* (B. ob-tec'tus).—This species resembles the preceding quite closely; but it is a little smaller (Fig. 709), and lacks the white markings characteristic of *B. pisi*. It infests beans, and often several individuals inhabit a single bean. The eggs are laid within the pod, being pushed through a slit which the female gnaws through the pod. This species will oviposit on dry beans, peas, and other grain, and will continue to breed for many generations in stored beans and peas.

Family TENEBRIONIDÆ (Te-neb-ri-on'i-dæ).

The Darkling Beetles.

The darkling beetles are nearly all of a uniform black color, although some are gray, and a few are marked with bright colors. The different species vary greatly in size and

in the form of the body. As with the blister-beetles, the hind tarsi are four-jointed, and the fore and middle tarsi are five-jointed; but unlike the members of that family, the body and wing-covers are firm, and the head is narrower than the prothorax.

These insects occur chiefly in dry and warm regions. Thus while we have comparatively few species in the Northeastern United States, there are many in the Southwest. Most of the species feed on dry vegetable matter, and often on that which is partially decomposed; some live in dung, some in dead animal matter, others in fungi, and a few prey upon larvæ. More than four hundred species occur in this country. The three following will serve to illustrate the variations in form and habits: —

The Meal-worm, *Tenebrio molitor* (Te-neb′ri-o mol′i-tor). —This is a well-known pest in granaries and mills. The larva is a hard, waxy-yellow, cylindrical worm, which measures when full grown an inch or more in length, and closely resembles a wire-worm; it feeds on flour and meal. The beetle is black, and about five eighths of an inch in length (Fig. 710).

FIG. 710.

The Forked Fungus-beetle, *Boletotherus bifurcus* (Bol-et-o-the′rus bi-fur′cus), is common in the Northeastern United States and in Canada about the large toadstools (*Polyporus*) which grow on the sides of trees. The surface of the body and wing-covers is very rough, and the prothorax bears two prominent horns (Fig. 711). The larva lives within the fungi referred to above.

FIG. 711.

The Pinacate-bugs (Pin-ah-cah′te-bugs).—Several species of *Eleodes* (El-e-o′des) are abundant on the Pacific coast, where they are found under stones and pieces of wood lying on the ground. They are apt to congregate in large numbers under a single shelter, and are clumsy in their movements. They defend themselves when disturbed by elevating the hinder part of

the body and discharging an oily fluid from it. They present an absurd appearance, walking off clumsily, and carrying the hind end of the body as high as possible. The most common species are large, smooth, club-shaped beetles (Fig. 712), and are commonly known as Pinacate-bugs. These beetles and those belonging to several closely allied genera are wingless.

Fig. 712.

The family ÆGIALITIDÆ (Æ-gi-a-lit′i-dæ) was founded upon a single species from Alaska; recently another has been found in California.

The family CISTELIDÆ (Cis-tel′i-dæ) includes about fifty North American species, some of which are quite common. These are brownish beetles, without spots, which are found on leaves and flowers and under bark. The body is usually elongate, elliptical, and quite convex. They are most easily distinguished from allied families by the tarsal claws being pectinate, and the anterior coxal cavities closed behind. The larvæ of some of our species at least live in rotten wood and resemble wire-worms in appearance.

The family OTHNIIDÆ (Oth-ni′i-dæ) is represented in our territory by four species of *Othnius* (Oth′ni-us), one from the East and three from the far West. They are small beetles, which are found running actively on the leaves of trees, and are probably predaceous. In this family the anterior coxal cavities are closed behind, and none of the abdominal segments are grown together on the ventral side.

The family LAGRIIDÆ (La-gri′i-dæ) includes only five North American species, all of which are from the East, and are found under bark and on leaves. They are elongate beetles, with a narrow, subcylindrical prothorax, and a more or less brassy color. Our most common species is *Arthromacra ænea* (Ar-thro-ma′cra æ′ne-a). This species is nearly half an inch in length (Fig. 713).

Fig. 713.

The family MONOMMIDÆ (Mo-nom′mi-dæ) is represented in this country by a single genus, including four

species. They are small, black, oval, heteromerous beetles, in which the anterior coxal cavities are open behind; and in which the antennæ are received in grooves on the under side of the prothorax.

The family MELANDRYIDÆ (Mel-an-dry'i-dæ) includes about sixty North American species. These are found under bark and in fungi. They are usually of elongate form, although some, like the one figured here, are not so. The maxillary palpi are frequently very long and much dilated; and the first segment of the hind tarsi is always much elongated. Among our more common species are two belonging to the genus *Penthe* (Pen'the). These are rather large, oval, depressed beetles, upwards of half an inch in length, and of a deep black color. *Penthe obliquata* (P. ob-li-qua'ta) is distinguished by having the scutellum clothed with rust-red hairs (Fig. 714). *Penthe pimelia* (P. pi mel'i-a) closely resembles this species, except that the scutellum is black.

FIG. 714.

The family PYTHIDÆ (Pyth'i-dæ) includes less than a score of North American species. Some of these live under bark; others are found under stones. They are heteromerous beetles, in which the anterior coxal cavities are open behind, the head is not strongly and suddenly constricted at base, and the prothorax is not margined at the sides.

The family ŒDEMERIDÆ (Œd-e-mer'i-dæ) is composed of heteromerous beetles of moderate size, with elongate, narrow bodies. The head and prothorax are somewhat narrower than the wing-covers; the antennæ are long, nearly filiform, sometimes serrate; the anterior coxal cavities are open behind, and the middle coxæ are very prominent. Less than fifty North American species have been described. They are generally found on plants, but some live on the ground near water.

The family CEPHALOIDÆ (Ceph-a-lo'i-dæ) includes only a single genus, which is represented in this country by but

three species. These are heteromerous beetles, which can be easily recognized by the characters given in the table of families.

The family MORDELLIDÆ (Mor-del'li-dæ) includes a large number of small beetles, which are easily recognized by their peculiar form (Fig. 715). The body is arched, the head being bent down; and the abdomen is usually prolonged into a slender point. Our most common species are black; but many are variegated, and all are pubescent. The adults are usually found on flowers; the larvæ live in rotten wood and in the pith of various plants, upon which they are supposed to feed.

FIG. 715.

The family ANTHICIDÆ (An-thic'i-dæ) includes beetles of moderate or minute size. The head is strongly constricted behind the eyes, and the neck is slender; the prothorax is narrower than the wing-covers at base. Many of the beetles live on flowers and leaves; but some are found near the margin of water. Our most common species belong to the genus *Notoxus* (No-tox'us), in which the prothorax is prolonged over the head into a horn.

The family PYROCHROIDÆ (Pyr-o-chro'i-dæ) includes a small number of beetles, which are from one third to three fourths of an inch in length. The body is elongate; the head and prothorax are narrower than the wing-covers; the antennæ are serrate or subpectinate in the females and usually flabellate in the males (Fig. 716). The beetles are found about decaying trees, beneath the bark of which the larvæ live.

FIG. 716.

Family MELOIDÆ (Me-lo'i-dæ).

The Blister-beetles.

The blister-beetles are of medium or large size. The body is comparatively soft; the head is broad, vertical, and abruptly narrowed into a neck; the prothorax is narrower

than the wing-covers, which are soft and flexible; the legs are long and slender; the hind tarsi are four-jointed, and the fore and middle tarsi are five-jointed.

These beetles are found on foliage and on flowers, on which they feed in the adult state; some of the species are very common on goldenrod in the autumn; and several species feed on the leaves of potato.

The blister-beetles are so called because they are used for making blister-plasters. The beetles are killed, dried, and pulverized, and the powder thus obtained is made into a paste, which when applied to the skin produces a blister. The species most commonly used is a European one, commonly known as the Spanish-fly; but our American species possess the same blistering property.

The transformations of blister-beetles are remarkable; not only do these insects undergo wonderful changes in form, but the number of these changes is greater than is usual with insects. On this account their mode of development is termed hypermetamorphosis.

The beetles lay their eggs in the ground. The newly-hatched larva is active, running about in search of its food, which consists, in some species, of the eggs of locusts, in others of the egg and honey of some solitary bee.

In the case of those species that live in the nests of bees the larva finds its home in a curious way. Instead of hunting for a nest it merely climbs a plant, and remains near a flower till it has a chance to seize hold of a bee visiting the flower. The larva clings to the bee until she goes to her nest, then, letting go of the bee, it remains in the cell and is shut up there with the egg of the bee and the store of food which she provides for her young. The beetle larva then devours the egg; after which it moults and undergoes a change of form, becoming a clumsy creature, which feeds upon the honey. Several other changes in form occur before the beetle reaches the adult stage.

The wonderful instinct by which the larvæ of these

blister-beetles find their way to the nests of solitary bees has not yet reached perfection; for many of the larvæ attach themselves to flies, wasps, honey-bees, and other flower-visiting insects, and merely gain useless transportation thereby.

Nearly two hundred species of blister-beetles have been found in this country. The majority of our common species belong to the genera named below.

Meloe.—The beetles of this genus present an exception to the characters of the Coleoptera, in that the wing-covers, instead of meeting in a straight line down the middle of the back, overlap at the base (Fig. 717). These wing-covers are short, and the wings are lacking. These beetles are called oil-beetles in England, on account of the yellowish liquid which oozes from their joints in large drops when they are handled. Our most common species is the Buttercup Oil-beetle, *Meloe angusticollis* (Mel'o-e an-gus-ti-col'lis). It may be found in meadows and pastures feeding on the leaves of various species of buttercups.

FIG. 717.

Nemognatha.—The species of the genus *Nemognatha* (Ne-mog'na-tha) are remarkable for having the maxillæ developed into a long sucking-tube, which is sometimes as long as the body, and which resembles somewhat the sucking-tube of a butterfly. A similar modification of the maxillæ occurs in the genus *Gnathium* (Gnath'i-um), which differs from *Nemognatha* in having a slight thickening of the outer segments of the antennæ. The species of these two genera occur chiefly in the South and West.

Our most common species of blister-beetles in the East belong to the genus *Epicauta* (Ep-i-cau'ta). These insects feed in the adult state upon the leaves of potato, and upon the pollen of goldenrod; the larvæ, so far as is known, are parasitic in the egg-cases of locusts. The Pennsylvania Blister-beetle, *Epicauta pennsylvanica*, (E. penn-syl-van'i-ca),

is of a uniform black color (Fig. 718). *Epicauta cinerea* (E. ci-ne′re-a) is sometimes clothed throughout with an ash-colored pubescence, and sometimes the wing covers are black, except a narrow gray margin; the two varieties were formerly considered distinct species: the first is commonly known as the ash-colored Blister-beetle, the last as the Margined Blister-beetle. Another common species is the Striped Blister-beetle, *Epicauta vittata* (E. vit-ta′-ta); this species is yellowish or reddish above, with the head and prothorax marked with black, and with two black stripes on each wing-cover.

FIG. 718.

In the far West very many species of blister-beetles occur—so many, in fact, that we cannot undertake to specify them here.

The family RHIPIPHORIDÆ (Rhip-i-phor′i-dæ) includes a small number of beetles, which are very remarkable in structure and habits. The wing-covers are usually shorter than the abdomen, and narrowed behind (Fig. 719); sometimes they are very small, and in one exotic genus they are wanting in the female, which lacks the wings also, and resembles a larva in form. The antennæ are pectinate or flabellate in the males, and frequently serrate in the females. The adult insects are found on flowers. The larvæ that are known are parasites, some in the nests of wasps, and some on cockroaches.

FIG. 719.

The family STYLOPIDÆ (Sty-lop′i-dæ) includes a small number of minute insects which differ so much from ordinary beetles that they have been classed by some writers as a distinct order, the *Strepsiptera* (Strep-sip′te-ra). In the males the elytra are reduced to slender, leathery, club-shaped appendages; while the wings are very large, fan-shaped, and furnished with a few diverging veins. The females have neither wings nor elytra, and resemble a larva in form. They are always contained in the pupa case in the body of a wasp or bee, which they infest parasitically. The point

of attack of these parasites is between two abdominal segments of the host. The presence of one of these parasites is indicated by an irregularity in the outline of the abdomen of the infested wasp or bee; and, too, the heads of the pupa cases of the parasites can be seen projecting from the suture. "The head of the pupa case of the male is convex, that of the female is flat; specimens containing male pupæ can be kept confined with proper food until the parasite is hatched." (Le Conte and Horn.) Two genera occur in this country, *Stylops* (Sty'lops), which infests bees of the genus *Andrena* (An-dre'na), and *Xenos* (Xe'nos), which infest wasps of the genus *Polistes* (Polis'tes). Certain foreign genera infest ants, cockroaches, and homopterous insects.

Suborder RHYNCHOPHORA (Rhyn-choph'o-ra).

The Snout-beetles.

This suborder includes the insects commonly called snout-beetles, of which ten families are represented in North America. With these insects the head is more or less prolonged into a beak, which is sometimes longer than the remainder of the body. The most distinctive characteristics of this suborder are the absence of the gula, there being only a single gular suture (Fig. 720, *gs*), and the fact that the epimera of the prothorax meet on the middle line behind the prosternum (Fig. 720).

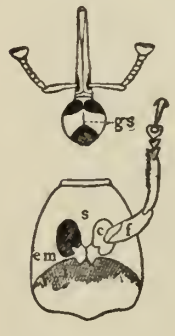

FIG. 720.

A monograph of the North American species of this suborder by Le Conte and Horn is published by the American Philosophical Society, Philadelphia.

The family RHINOMACERIDÆ (Rhin-o-macer'i-dæ) includes a small number of Snout-beetles in which the elytra have no fold on the lower surface near the outer edge, but in which the labrum is distinct. The head is prominent, not deflexed; the snout is as long as the prothorax, rather flat, narrowest about the middle, wider

at base and tip; the elytra are rounded at the tip and entirely cover the abdomen. These beetles infest the staminate flowers of coniferous trees, in which the eggs are laid.

The family RHYNCHITIDÆ (Rhyn-chit'i-dæ) includes Snout-beetles in which the elytral fold is very feeble, the labrum is wanting, and in which the mandibles are toothed both on the outer and inner side. The mandibles can be spread widely, and when closed the outer tooth at the end of each projects forward so that two small acute teeth seem to project from the mouth.

The most common member of this family is *Rhynchites bicolor* (Rhyn-chi'tes bi'co-lor) (Fig. 721). This is red above, except the snout, and black below; the body, not including the snout, is about one fourth inch long, the snout is half that length. The adults are often abundant on wild roses.

FIG. 721.

The family ATTELABIDÆ (At-te-lab'i-dæ), or *Leaf-rolling Weevils* is composed of beetles that have neither an elytral fold nor a labrum, and in which the mandibles are flat, pincer-shaped, and toothed on the inner side. The elytra do not entirely cover the abdomen, and each is separately rounded at the tip. Only five species are known from this country, four from the Atlantic States, and one from New Mexico; all belong to the genus *Attelabus* (At-tel'a-bus). The females provide for their young in a very remarkable way. They make compact thimble-shaped rolls from the leaves of trees (Fig. 722) and lay a single egg in each. The larvæ feed on the inner parts of these rolls, and when full grown enter the ground to transform. Sometimes these rolls are found hanging by a narrow piece to the leaf from which they were made, and sometimes they are found lying on the ground separated from the leaf.

FIG. 722.

The family BYRSOPIDÆ (Byr-sop'i-dæ) is represented in North America by a single species, *Thecesternus humeralis*

(Thec-e-ster'nus hu-mer-a'lis), of the central portion of the United States. It usually lives near the surface of the ground, but has been found attacking grape-vines and hickory. It is a grayish beetle, one third to one half inch in length, and with its wing-covers roughened by rows of tubercles. Its distinctive structural characters are given in the table of families.

Family OTIORHYNCHIDÆ (O-ti-o-rhyn'chi-dæ).

The Scarred Snout-beetles.

This is one of the larger of the families of snout-beetles, including more than one hundred North American species. The most distinctive characteristic of these insects is the presence in the pupa state, and sometimes also in recently matured adults, of an appendage on each mandible, and in the adult state of a scar indicating the place from which the appendage has fallen. This scar is on the anterior face of the mandible, and frequently at the tip of a slight process. Many species of this family are beautifully ornamented with scales which resemble in a striking manner the scales on the wings of butterflies. Among the more important species are the following :

Fuller's Rose-beetle, *Aramigus fulleri* (A-ram'i-gus ful'le-ri).—This is an oval, black snout-beetle, lightly covered with dark-brown scales, and about one fourth inch in length. It is very destructive to roses ; the larvæ feed upon the roots, and the adults destroy the leaves, flowers, and buds. In California it is sometimes a pest in orange-groves.

FIG. 723.

The Imbricated Snout-beetle, *Epicærus imbricatus* (Ep-i-cæ'rus im-bri-ca'tus) is usually a dull, silvery-white beetle with brown markings ; but the species is quite variable in color. It is represented somewhat enlarged by Figure 723. It is omnivorous, gnawing holes in various garden vegetables and fruits, and in the bark of trees and shrubs.

Family CURCULIONIDÆ (Cur-cu-li-on'i-dæ).

The Curculios (Cur-cu'li-os) or Weevils.

The Curculionidæ is the most important of the families of snout-beetles; it includes more than one half of all the Rhynchophora found in this country, and some of the most destructive insect pests. In this family there is on the lower side of each wing-cover a strong fold near the outer margin, which limits a deep groove in which the upper edge of the abdomen fits; the mandibles have no scar; the antennæ are usually elbowed, and have a ringed or solid club; the tarsi are usually dilated, with the third segment bilobed and spongy beneath; in a few cases the tarsi are narrow, but not spinose beneath.

The larvæ are soft, white, maggot-like grubs destitute of feet. They feed chiefly on fruits, seeds, and nuts; but all parts of plants are subject to their attacks.

In laying her eggs, the female first bores a hole with her snout, then drops an egg into this hole, and finally pushes the egg to the bottom of the hole with her snout. In many species the snout is highly developed for this purpose; sometimes it is twice as long as the remainder of the body. This is well shown in the acorn-weevils and the nut-weevils, which belong to the genus *Balaninus* (Ba-lan'i-nus). Figure 724 represents *Balaninus quercus* (B. quer'cus) resting on an acorn; the specimen figured, when found had her snout inserted in the acorn up to the antennæ.

FIG. 724.

Of the closely allied species *B. rectus* (B. rec'tus) breeds in acorns, *B. nasicus* (B. na-si'cus) in hickory-nuts, and *B. caryatrypes* (B. car-y-a-try'pes) in chestnuts.

Probably the most important member of this family from an economic standpoint is the Plum Curculio, *Conotrachelus nenuphar* (Con-o-tra-che'lus nen'u-phar). This is the insect that stings plums, often destroying a large proportion of the

fruit; the larva is also the well-known grub or "worm" of "wormy" cherries. The presence of this insect in an orchard can be determined early in the season by a peculiar mark it makes when laying its eggs in the young fruit. The female beetle makes an incision, with her snout, through the skin of the fruit. In this incision she lays a single egg, which she pushes with her snout to the bottom of the cavity that she has prepared. She then makes a crescent-shaped incision in front of the one containing the egg. This last cut undermines the egg, leaving it in a little flap. The larvæ feed within the fruit. In the case of plums the infested fruit falls to the ground; but not so with cherries. When full grown the larvæ usually go into the ground to transform; a few transform within the fruit. This species infests nectarines, apricots, and peaches as well as plums and cherries. This insect is fought in two ways: the beetles are jarred from the trees upon sheets in early spring, and destroyed before they have laid their eggs; they are also poisoned by spraying the trees with Paris-green-water before the fruit is large enough for them to oviposit in it The adult beetle feeds upon the foliage, and can thus be poisoned.

As yet this species does not occur on the Pacific coast, and the greatest care should be taken that it be not introduced there.

The Apple-weevil, *Anthonomus quadrigibbus* (An-thon'omus quad-ri-gib'bus), infests the fruit of apple. The specific name was suggested by the fact that there are two wart-like projections near the hinder end of each wing-cover.

The Strawberry-weevil, *Anthonomus signatus* (A. signa'tus), is sometimes a serious pest in strawberry plantations. The adult beetle (Fig. 725) punctures the pedicel of the flower a short distance below the buds, and lays her eggs within the buds. The buds drop to the ground, and the larvæ, one in each, develop within them.

FIG. 725.

The family BRENTHIDÆ (Bren'thi-dæ) is confined chiefly

to tropical regions, and, except in the far South, only a single species occurs in this country. This species is the Northern Brenthid, *Eupsalis minuta* (Eu'psa-lis mi-nu'ta), which is represented by Figure 726. In the female the head is prolonged into a slender snout; but in the male the snout is broad and flat, and is armed with a pair of powerful jaws. These are weapons of offence, for the males fight desperately for their mates; and, too, the males are generally larger than the females—an unusual occurrence among insects. It is interesting, as has been pointed out by Mr. A. R. Wallace in his "Malay Archipelago," "as bearing on the question of sexual selection, that in this case, as in the stag-beetles, where the males fight together, they should be not only better armed, but also much larger than the females."

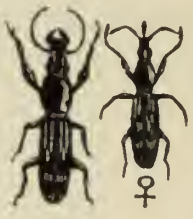

FIG. 726.

The Northern Brenthid is found upon oak-trees, in the solid wood of which the larvæ bore, and is widely distributed over the United States and Canada.

One species of *Brenthus* is found in Southern Florida and two in Lower California. In this genus the snout is slender in both sexes.

The only other representative of this family that occurs on this continent north of Mexico is the Sweet Potato Root-borer, *Cylas formicarius* (Cy'las for-mi-ca'ri-us), of Louisiana and Florida. This beetle is somewhat ant-like in form; the color of the elytra, head, and snout is bluish black, that of the prothorax reddish brown.

Family CALANDRIDÆ (Ca-lan'dri-dæ).

The Bill-bugs.

To this family belong some of our most common snout-beetles. Here the lateral edge of the metathorax and of the abdomen fits into a groove in the wing-cover, and the surface of the wing-cover in this groove has a pearly lustre;

the pygidium of both sexes is undivided, and may be covered or uncovered by the wing-covers, but is not surrounded at the edge by them, as in the Scolytidæ; the tibiæ are not serrate; the antennæ are elbowed; and the labrum is wanting. The larvæ of the larger species bore in the stems of plants, while those of the smaller species infest grains and seeds.

Among the more common members of this family are several species of the genus *Sphenophorus* (Sphe-noph'o-rus); one of these is represented by Figure 727. These are of medium or rather large size, and are often marked in a very characteristic manner by longitudinal, elevated bands of darker color.

FIG. 727.

One of the most important members of the family, from an economic standpoint, is the Rice-weevil, *Calandra oryzæ* (Ca-lan'dra o-ry'zæ). This is a small snout-beetle, measuring only one fifth inch in length. It is usually black, but sometimes it is of pale-chestnut color, or some shade between the two. It is exceedingly abundant, especially in the Southern States, where it does great injury to stored grain of all kinds.

Family SCOLYTIDÆ (Sco-lyt'i-dæ).

The Engraver-beetles.

If the bark be pulled from dead branches or trunks of trees, the inner layer and the sap-wood will be found to be ornamented in many cases with burrows of more or less regular form. These smoothly cut figures are the mines of the engraver-beetles. Many kinds of these engravings can be found, each characteristic of a particular kind of engraver-beetle. A common pattern is shown in Figure 728.

The beetles that do this work are mostly of cylindrical form and of small size; many species are almost microscopic, and the larger ones rarely exceed a quarter of an inch in length. They are usually brown, sometimes black; and

with many the hind end of the body is very blunt, as if cut off. The antennæ are elbowed or bent in the middle, and are clubbed at the tip; the tibiæ are usually serrate; the

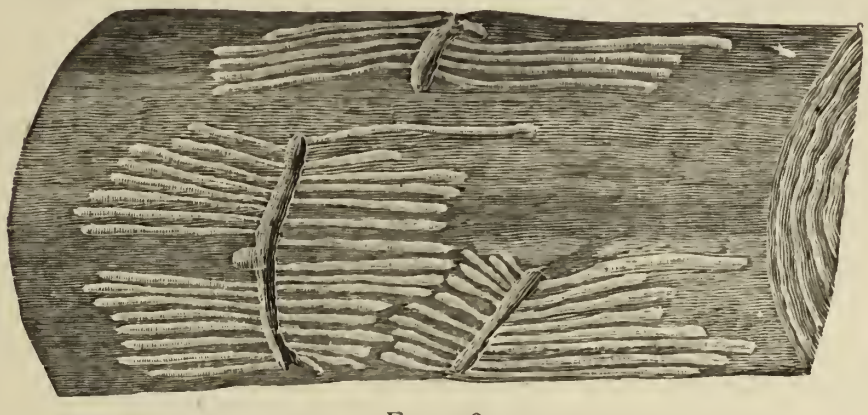

FIG. 728.

pygidium is surrounded at the edge by the wing-covers, which have the fold on the inner surface well developed.

The members of this family feed almost exclusively on woody plants. Most of the species make burrows between the bark and the wood; but many species bore directly into the solid wood, and one well-known pest lives in the roots of herbaceous plants.

In the case of the kind of burrow figured above and other similar ones the central tunnel is made by the mother beetle. While doing this she makes a series of niches along each side of this tunnel, and lays an egg in each. When the larvæ hatch, each one deepens its niche, and thus makes a burrow at right angles to that of the parent beetle.

In the case of a European species, *Tomicus typographus* (Tom'i-cus ty-pog'ra-phus), Dr. K. Lindeman, a Russian naturalist, has discovered that the original tunnel is begun by the male, which makes a little chamber in the bark; afterwards the female comes to him in this chamber, and later she continues the mine begun by her mate, making the long central tunnel from which the tunnels of her offspring extend. Thus we see that all of the members of a single family have a share in making one of these engravings. It

is probable that the males of other species have similar habits, but how general this is has not yet been determined.

The members of this family are among the most injurious of the insect enemies of forest-trees. Frequently the trees are killed outright; in other cases, although the life of the tree is not endangered, the timber is greatly injured by the burrows. Occasionally fruit-trees are also injured by members of this family.

Figure 729 represents one of the larger of our common species, *Dendroctonus tenebrans* (Den-droc'to-nus ten'e-brans). This is a light-yellowish beetle, which lives under the thick bark of pine logs and stumps. It is about one fourth of an inch in length.

FIG. 729.

The Clover-root Borer, *Hylesinus trifolii* (Hy-les'i-nus tri-fo'li-i).—This is a European insect, which has found its way to this country, and become a very serious pest in the Eastern States. It differs markedly from most of the members of this family in that it makes irregular burrows in the roots of herbaceous plants. It infests clover and allied plants. In many places in the East a large proportion of the two-year-old clover plants are infested by it. In the autumn larvæ, pupæ, and adults are found in the roots of such plants, and the adults remain here throughout the winter.

The family ANTHRIBIDÆ (An-thrib'i-dæ) includes a small number of snout-beetles, in which the fold on the lower surface of the wing-covers is present, the pygidium of both sexes is undivided, the antennæ are not elbowed, and the labrum is present. The larvæ, as a rule, infest seeds and the stems of plants; some of them are said to have short but well-developed legs. The larvæ of the genus *Brachytarsus* (Brach-y-tar'sus), which are very small, are supposed to be parasitic on scale-insects.

CHAPTER XXII.

Order HYMENOPTERA (Hy-me-nop'te-ra).

Bees, Wasps, Ants, and others.

The members of this order have four wings; these are membranous, and furnished with comparatively few or with no transverse veins. The hind wings are smalier than the fore wings. The mouth-parts are formed for biting and sucking. The abdomen in the females is usually furnished with a sting, piercer, or saw. The metamorphosis is complete.

The bees, wasps, and ants are among the better-known insects, and will serve to give an idea of the characteristic appearance of the members of this order. They are chiefly insects of small or moderate size, and many of them abound wherever flowers bloom. From the earliest times they have been favorites with students of the habits of animals, for among them we find the most wonderful developments of instinctive powers. Many volumes have been written regarding their ways, and much remains to be discovered, even concerning our most common species.

The name of the order is from two Greek words—*hymen*, membrane, and *pteron*, a wing. It refers to the fact that the wings are of a delicate membranous texture; but this characteristic is not distinctive, for it is possessed by the wings of many other insects.

In the Hymenoptera the wings of each side are held together by a row of hooks on the front margin of the hind

wing. These hooks fasten to a fold in the hind margin of the front wing, so that the two wings present a continuous surface. (Fig. 730).

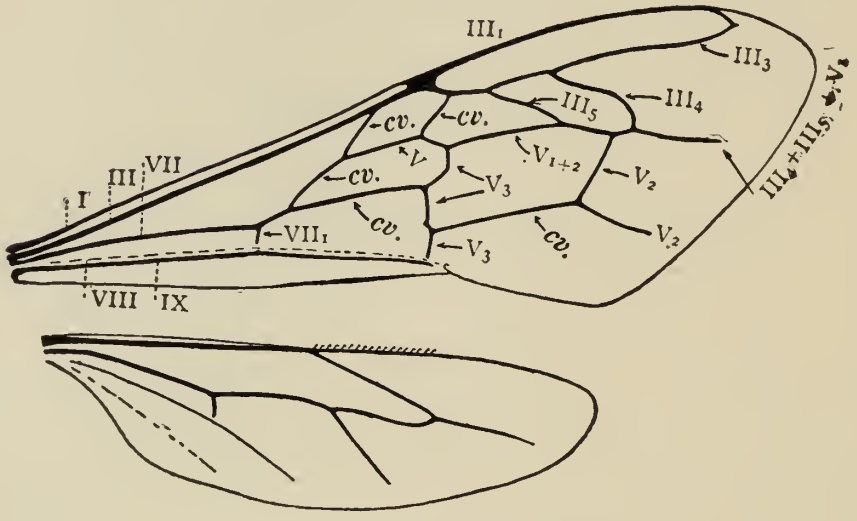

FIG. 730.—Wings of the honey-bee.

With other insects the mouth-parts, if well developed, are formed either for biting or for sucking, but in this order they are adapted to serve both purposes (Fig. 731). The mandibles are fitted for biting, and they are sometimes very powerful. The maxillæ, in the typical members of the order, are long, membranous or leathery, and form a sheath to the labium, the three organs thus constituting an apparatus for sucking or lapping liquid food. The maxillary and the labial palpi are present.

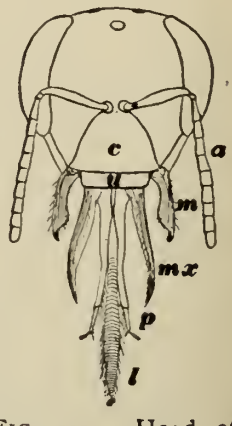

FIG. 731. — Head of the honey-bee: *a*, antenna; *c*, clypeus; *u*, labrum; *m*, mandibles; *mx*, maxilla; *p*, labial palpus; *l*, labium.

The larvæ of Hymenoptera are usually footless, maggot-like creatures, incapable of any extended motion, and entirely dependent on the provision made for them by the adult insects. But in the two lower families the larvæ are furnished with legs, and frequently have a striking resemblance to caterpillars, both in form and in habits. When the larvæ are full grown they transform to inactive pupæ, which

have all of the limbs of the adult insect inclosed in sheaths, and folded upon the breast. With many species the larva, before changing to a pupa, spins a cocoon about its body. With some this cocoon is composed of comparatively loose silk, and resembles somewhat the cocoon of a moth. In others the cocoon is of a dense parchment-like texture, and in still others it resembles a very delicate foil.

Although there are very many species of Hymenoptera, the number of families is not large. The following synopsis will aid the student in fixing in his mind the relationships of the different families: —

SYNOPSIS OF THE HYMENOPTERA.

THE BORING HYMENOPTERA, Suborder TEREBRANTIA. p. 610.
The Plant-eating Hymenoptera.
The Saw-flies, Family TENTHREDINIDÆ. p. 611.
The Horn-tails, Family SIRICIDÆ. p. 614.
The Gall-inhabiting Hymenoptera.
The Gall-flies, Family CYNIPIDÆ. p 615.
The Parasitic Hymenoptera.
The Trigonalids, Family TRIGONALIDÆ. p. 621.
The Ichneumon-flies, Family ICHNEUMONIDÆ. p. 621.
The Stephanids, Family STEPHANIDÆ. p. 624.
The Braconids, Family BRACONIDÆ. p. 625.
The Ensign-flies, Family EVANIIDÆ. p. 626.
The Chalcis-flies, Family CHALCIDIDÆ. p. 628.
The Proctotrupids, Family PROCTOTRUPIDÆ. p. 630.
THE STINGING HYMENOPTERA, Suborder ACULEATA. p. 631.
The Pelecinus, Family PELECINIDÆ. p. 631.
The Cuckoo-flies, Family CHRYSIDID.Æ p. 632.
The Ants, Superfamily FORMICINA. p. 633.
Family FORMICIDÆ. p. 640.
Family PONERIDÆ. p. 642.
Family MYRMICIDÆ. p. 642.
The Digger-wasps, Superfamily SPHECINA. p. 644.
The Velvet-ants, Family MUTILLIDÆ. p. 648.
The Scoliids, Family SCOLIIDÆ. p. 649.
The Sapygids, Family SAPYGIDÆ. p. 649.
The Spider-wasps, Family POMPILIDÆ. p. 650.

The Thread-waisted Wasps, Family SPHECIDÆ. p. 650.
The Ampulicids, Family AMPULICIDÆ. p. 647.
The Larrids, Family LARRIDÆ. p. 652.
The Bembecids, Family BEMBECIDÆ. p. 652.
The Nyssonids, Family NYSSONIDÆ. p. 654.
The Philanthids, Family PHILANTHIDÆ. p. 654.
The Mimesids, Family MIMESIDÆ. p. 655.
The Mellinids, Family MELLINIDÆ. p. 647.
The Pemphredonids, Family PEMPHREDONIDÆ. p. 655.
The Crabronids, Family CRABRONIDÆ. p. 656.
The True Wasps, Superfamily VESPINA. p. 657.
The Guest Wasps, Family MASARIDÆ. p. 657.
The Solitary Wasps, Family EUMENIDÆ. p. 658.
The Social Wasps, Family VESPIDÆ. p. 660.
The Bees, Superfamily APINA. p. 664.
The Short-tongued Bees, Family ANDRENIDÆ. p. 665.
The Long-tongued Bees, Family APIDÆ. p. 666.

Classification of the Hymenoptera.

(*For Advanced Students.*)

Nearly all of the technical terms used in the descriptions of Hymenoptera in this work have been defined already. For a general account of the external parts of these insects see pp. 56–66; for a more detailed description of the external anatomy of an insect, see the discussion of the external anatomy of beetles. pp. 499.

After a student has learned to recognize the sclerites in the body wall of a beetle, he will have but little trouble in determining the parts of a hymenopterous insect. The following points, however, should be carefully noted: —

The Propodeum.—A remarkable peculiarity of Hymenoptera is that the first abdominal segment is united with the thorax in such a way as to appear to be a part of it; and what appears to be the first abdominal segment, and is always called so, is really the second. The true first abdominal segment is called the *propodeum* (pro-po′-de-um).

The Tegulæ.—There is on each side of the second thoracic segment a cup-like scale over the base of the fore-wing (Fig. 732, 5); this is the parapteron (see p. 502). The paraptera of the mesothorax of Hymenoptera are termed the *tegulæ* (teg′u-læ); they correspond to the patagia of Lepidoptera and to the elytra of Coleoptera.

The Parapsides.—In this order the scutum of the mesothorax is divided into three parts by two longitudinal sutures; the lateral por-

FIG. 732.—A Chalcis-fly: 1, pronotum; 2, 2, parapsides; 3, mesal part of the scutum of the mesothorax; 4, scutellum; 5, tegulæ.

tions of the scutum thus separated from the mesal part (Fig. 732, 2, 2) are termed the *parapsides* (pa-rap'si-des).

The Wing-veins.—It is much more difficult to determine the homologies of the wing-veins of the Hymenoptera than those of either the Lepidoptera or the Diptera; for in this order the primitive plan is much more obscured. The best way to learn the wing-veins of the Hymenoptera is to make first a careful study of those of the Diptera, and then to compare the front wing of a generalized hymenopterous insect with a wing of one of the more generalized Diptera; for this purpose take the front wing of a saw-fly of the genus *Pamphilius* (Fig. 733) and that of *Tabanus* (Fig. 539, p. 454).

In *Pamphilius* (Pam-phil i-us), and in most other Hymenoptera also, the anal furrow or vein VIII is easily recognized as a concave fold, in the position indicated by the dotted line (Fig. 733, VIII). Having found this, a very important landmark is established.

Next it should be understood that the Hymenoptera belong to that series of orders in which veins IV and VI are not developed; therefore the veins that lie in front of the anal furrow are veins I, II, III, V, and VII.

Vein I forms the costal border of the wing, as in the Diptera (Fig. 733, I).

Vein II is usually absent in the Hymenoptera; but in *Pamphilius*, and in a few other genera, it is well preserved (Fig. 733, II). It is simple, and is usually connected with vein III by a cross-vein.

Vein III is the most difficult of all of the veins to understand. A very careful study of the problem has convinced the writer that this vein is typically five-branched in this order, resembling in this re-

spect the homologous veins in the Lepidoptera and Diptera. In the Hymenoptera the tips of the branches of vein III coalesce with other veins; and when this coalescence has proceeded for a considerable distance towards the base of the wing, the branches may appear like cross-veins, instead of branches of a longitudinal vein. This result is very similar to what takes place in the more specialized Diptera. In *Pamphilus* (Fig. 733) vein III_2 is wanting; but this vein is present in *Macroxyela* (mac rox-y-e'la) (Fig. 735). In both of these genera there is a cross-vein between veins III_1 and III_{2+5} (Fig. 733, *cv*). A similar cross-vein exists in some crane-flies, dividing cell

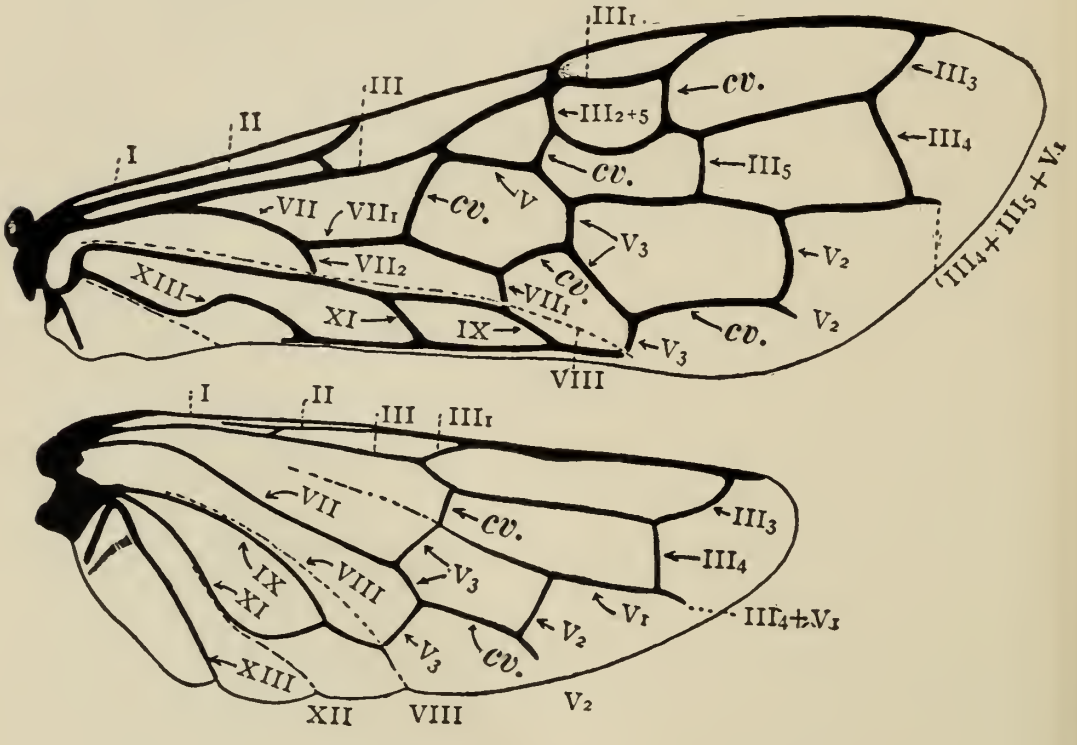

FIG. 733.—Wings of a saw-fly, *Pamphilius*, with the veins numbered.

III_1 into two parts (see Fig. 505). In both of these genera also the tips of veins III_4 and III_5 coalesce with vein V_1 to such an extent that these veins appear to be cross-veins. In the wing of the Honey-bee (Fig. 730) these veins are more obviously longitudinal veins.

Vein V is very similar to the homologous vein in the Diptera. It arises from a cross-vein extending from vein III to vein VII. In *Pamphilius* it arises from near the costal end of this cross-vein; but in *Apis* (Fig. 730) its origin is near the middle of the cross-vein. In the Hymenoptera, however, the cross-vein III–VII is much farther from the base of the wing than it is in the Diptera. In the more

generalized Hymenoptera vein V is three-branched, and veins V_2 and V_3 are connected by a cross-vein, as in the Diptera; but this cross-vein appears like a longitudinal vein (Fig. 733). The tip of vein V_3 has migrated from its primitive position on the outer margin of the wing to the anal furrow (vein VIII), and ends in this furrow at a greater or less distance from the margin of the wing (Fig. 733); the result of this migration is to pull the cross-vein V_2–V_3 into a longitudinal position.

Vein VII coalesces with vein III for a considerable distance from the base of the wing in *Pamphilius* (Fig. 733); but in *Apis* (Fig. 730), and in many other forms, it arises from the base of the wing. This vein is two-branched, as in the Lepidoptera and Diptera. The tips of the branches of vein VII have migrated from the margin of the wing to the anal furrow (vein VIII), and for a considerable distance along this furrow towards the base of the wing, so that both of these veins (VII_1 and VII_2) end in the anal furrow, far from the margin of the wing; the result of this migration is to pull the cross-vein V_3–VII_1 into a longitudinal position. In *Pamphilius* (Fig. 733) this cross-vein is nearly longitudinal; in *Apis* (Fig. 730) it is completely so. In *Pamphilius* vein VII_2 is very short, but well enough developed so that there is no doubt regarding the homology; but in most Hymenoptera it has completely disappeared.

In the area lying back of the anal furrow there also exists a tendency for veins to coalesce at their tips; this is well shown in both fore and hind wings of *Pamphilius;* and in the hind wings especially the united tips of veins IX and XI have migrated towards the base of the wing along the anal furrow (Fig. 733).

The concave veins of the anal area (veins X and XII) are rarely developed; in the hind wing of *Pamphilius* there is a fold which probably represents vein XII (Fig. 733).

The Cells of the Wing.—Having learned the venation of the wings it is easy to number the cells. There are, however, a few special terms that are used in works on this order; the more important of these are the following: —

In most Hymenoptera there is an opaque spot on the costa, a short distance beyond the middle of the wing; this is the *stigma* (Figs. 734 and 735, *s*). The stigma lies between vein III_1 and the margin of the wing; it is probably the apical portion of cell II. In Figure 733 it has not been blackened in order to show the course of vein III_1.

Usually vein III_1, after joining the costa at the end of the stigma, does not again separate from it, but is joined by the tip of vein III_3 before the apex of the wing (Fig. 733). But in certain families the

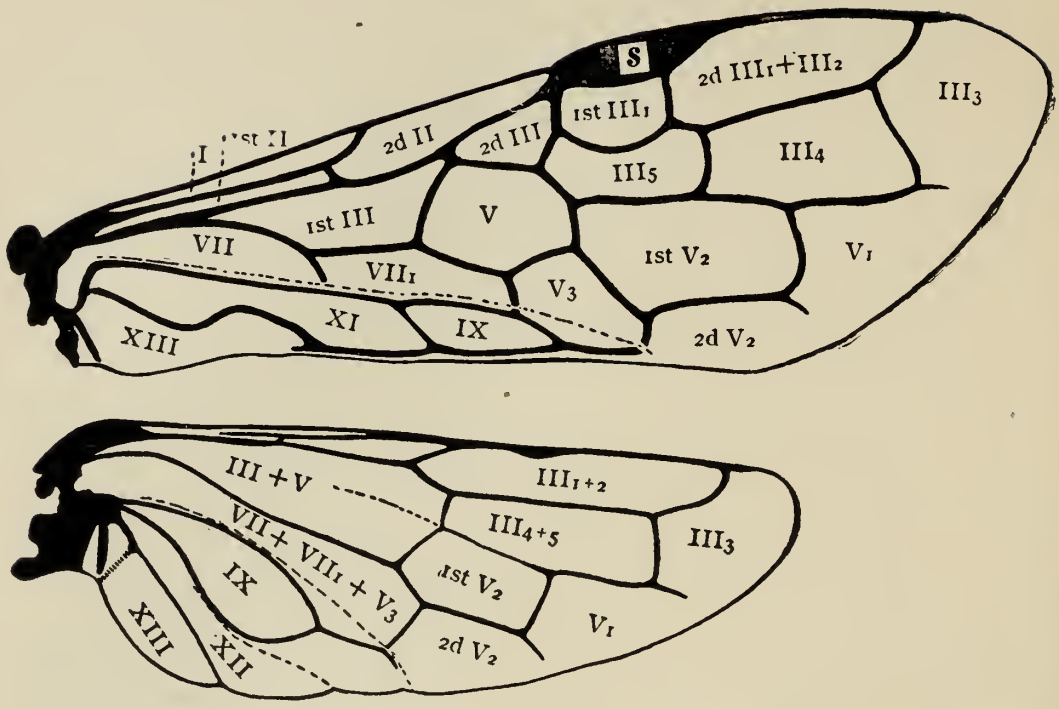

FIG. 734.—Wings of a saw-fly, *Pamphilius*, with the cells numbered.

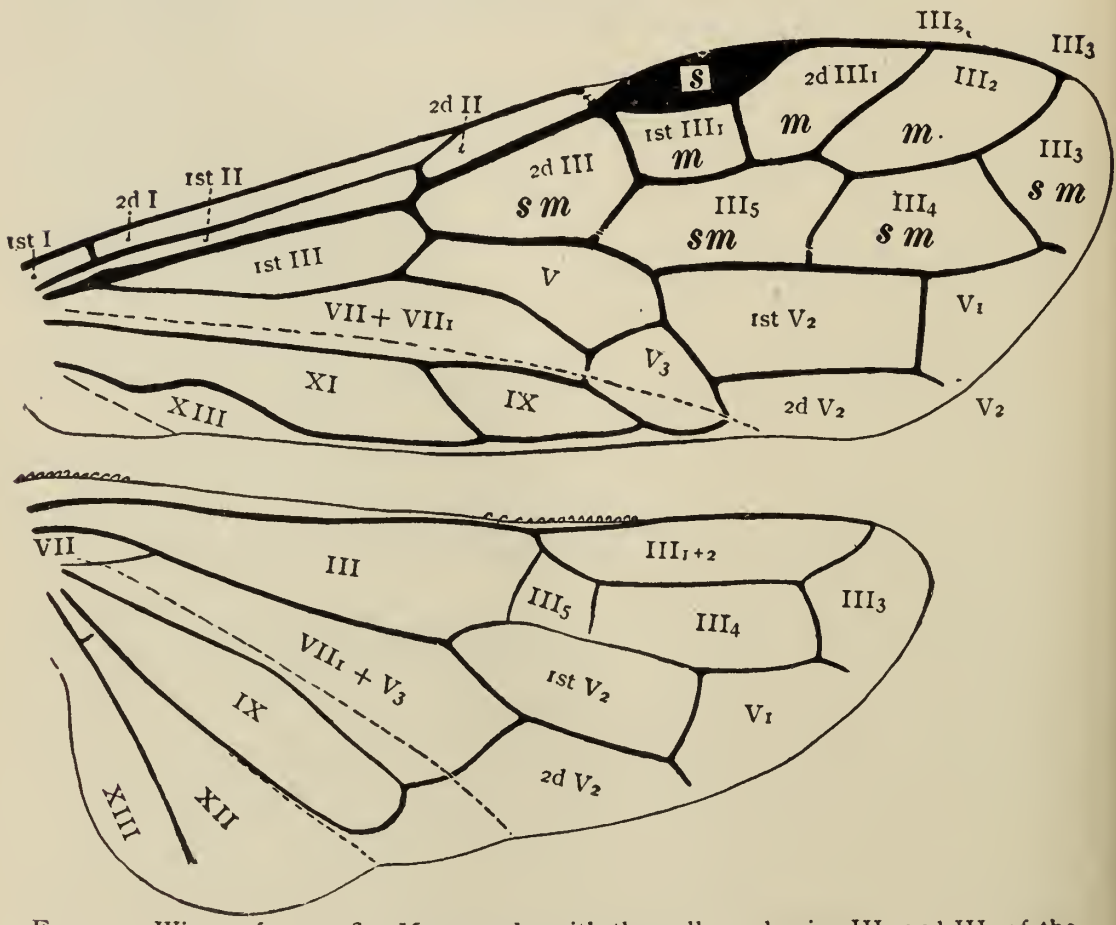

FIG. 735.—Wings of a saw-fly, *Macroxyela*, with the cells and veins III_2 and III_3 of the fore-wing numbered.

tip of vein III_1 separates from the costa and coalesces with the tip of vein III_3 at some distance from the costa. The space thus formed between the united tips of veins III_1 and III_3 and the costa is termed the *appendiculate cell* (Fig. 736, *ap*).

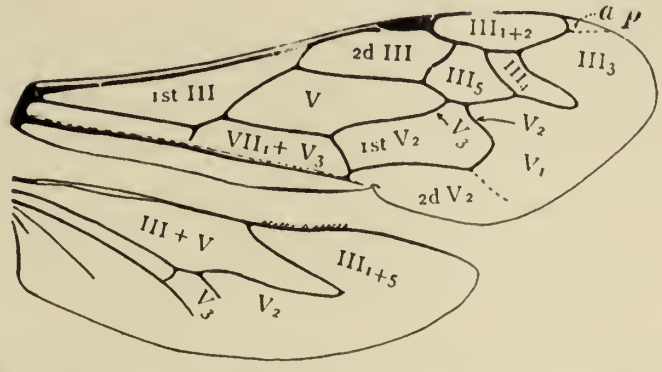

FIG. 736.—Wings of *Larra* with the cells numbered: *ap*, appendiculate cell.

The cells marked *m*, *m*, *m*, in Figure 735, are termed the *marginal cells;* and those marked *sm*, *sm*, *sm*, *sm*, the *submarginal cells.*

The following table for determining the families of the Hymenoptera has been compiled from the works of several writers on this order, and is merely provisional. It, however, will enable the student to determine the larger and more common forms; and in the present state of our knowledge the study of the minute Hymenoptera is too difficult for the beginner.

TABLE FOR DETERMINING THE FAMILIES OF THE HYMENOPTERA,

A. Trochanters of the posterior legs, consisting each of two segments (Fig. 737, b); caudal end of body in the female furnished with a saw or borer for depositing the eggs. (Suborder TEREBRANTIA.)

B. Abdomen joined broadly to the thorax.

C. Anterior tibiæ with two apical spurs; abdomen of female furnished with a pair of saws. p. 611 ..... TENTHREDINIDÆ.

CC. Anterior tibiæ with one apical spur; abdomen of female furnished with a borer. p. 614 ..... SIRICIDÆ.

BB. Base of abdomen constricted.

C. Abdomen joined to the dorsal aspect of the metathorax. p. 626. EVANIIDÆ.

CC. Insertion of the abdomen normal.

D. Fore wings with no closed cells.*

* In a few Proctotrupidæ the wings have one or more closed cells.

E. Borders of the mesoscutum intervening between the pronotum and the tegulæ (Fig. 738); ovipositor issuing before the apex of the abdomen. p. 628.....CHALCIDIDÆ.

EE. Pronotum extending to the tegulæ (Fig. 739); ovipositor issuing from the apex of the abdomen. p. 630. PROCTOTRUPIDÆ.

DD. Fore wings with several closed cells, or at least with a closed or nearly closed marginal or submarginal cell.*

E. Fore wings without a stigma. p. 615.....CYNIPIDÆ.

EE. Fore wings with a stigma.

F. Fore wing with the vein between cells V_1 and 1st V_2 wanting (Fig. 740).

G. Veins I–III of the fore wing consolidated from the base of the wing to the stigma. p. 625..BRACONIDÆ.

GG. Base of fore wing with a cell between veins I and III. p. 624.....STEPHANIDÆ.

FF. Fore wing with cells V_1 and 1st V_2 separate (Fig. 741).

G. Veins I–III of fore wing consolidated from the base of the wing to the stigma. p. 621...ICHNEUMONIDÆ.

GG. Base of fore wing with a cell between veins I and III. p. 621.....TRIGONALIDÆ.

AA. Trochanters of the posterior legs, consisting each of a single segment (Fig. 737, *a*); caudal end of body in female usually furnished with a sting. (Suborder ACULEATA.)

B. Fore wing with no closed submarginal cells.

C. Abdomen long; antennæ long, not elbowed, threadlike; body smooth and polished, black. p. 631..... PELECINIDÆ.

CC. Abdomen but little longer than the head and thorax; antennæ short, elbowed; body adorned with metallic colors, and often coarsely and deeply sculptured. 632.....CHRYSIDIDÆ.

BB. Fore wing with at least one closed submarginal cell.

C. First abdominal segment, and sometimes the second also, forming a lens-shaped scale or knot (Fig. 742); base of front wing not protected by a tegula. p. 633.....FORMICINA.

CC. Basal part of abdomen without a knot.

D. First segment of posterior tarsi cylindrical and naked, or with but little hair; hairs clothing thorax simple.

E. Wings not plated when at rest. p. 644.....SPHECINA.

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* Very rarely the wings are without closed cells in some Evaniidæ and Braconidæ.

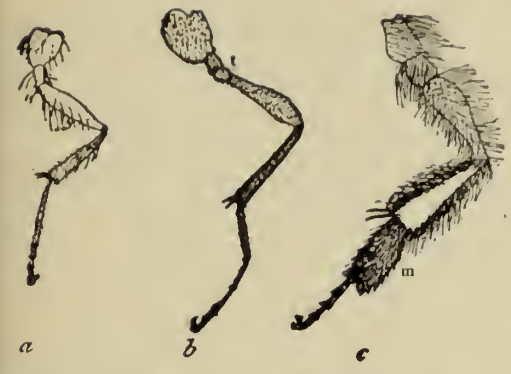

FIG. 737.—Legs of insects: *a*, wasp; *b*, Ichnuemon-fly; *c*, bee; *t*, trochanter; *m*, metatarsus.

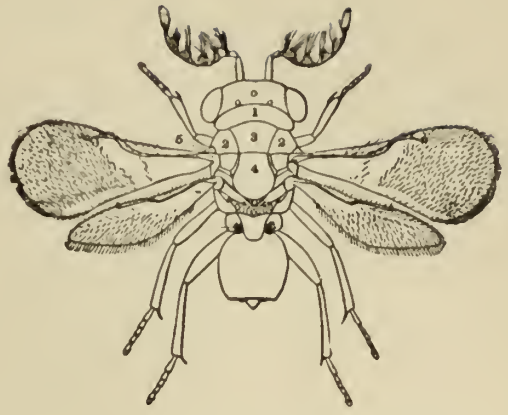

FIG. 738.—A Chalcis-fly: 1, pronotum; 2, 3, 2, mesoscutum; 5, tegula.

FIG. 739.—A Proctotrupid: 1, pronotum; 5, tegula.

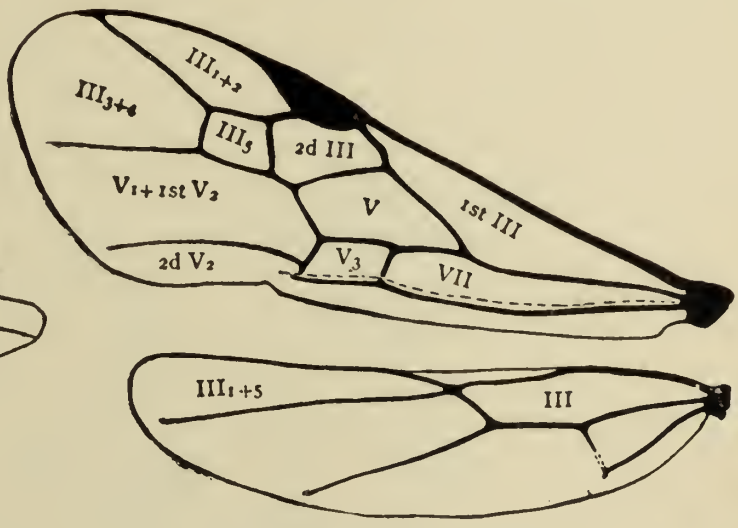

FIG. 740.—Wings of a Braconid.

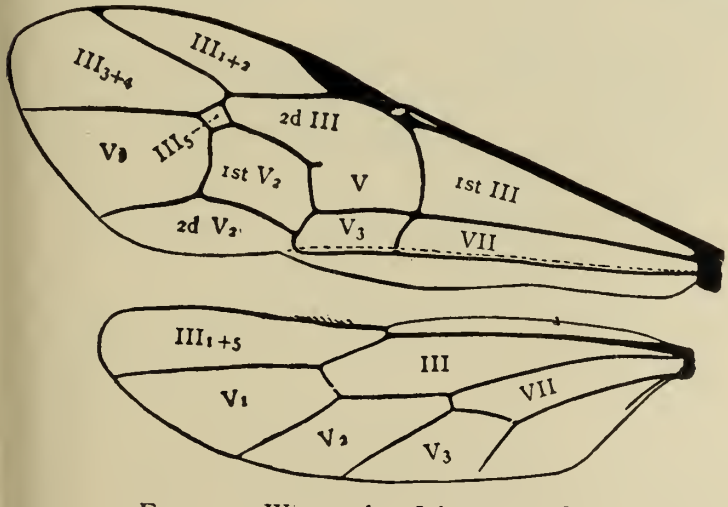

FIG. 741.—Wings of an Ichneumon-fly.

FIG. 742.

EE. Wings folded in plaits when at rest.* p. 657.

VESPINA.

DD. First segment of the posterior tarsi enlarged, flattened, and more or less clothed with hair; hairs clothing thorax plumose (Fig 737, *c*). p. 664..... .....APINA.

Suborder TEREBRANTIA (Ter-e-bran'ti-a).

The Boring Hymenoptera.

The Hymenoptera are divided into two suborders, the Boring Hymenoptera and the Stinging Hymenoptera. In the first of these suborders the caudal end of the abdomen of the female is furnished with an organ, the ovipositor, which is fitted for boring a hole into which an egg is to be placed, and also for conveying the egg into this hole. The form of the ovipositor varies greatly in the different families; in one the boring parts are represented by a pair of saws, by means of which slits are made in the leaves of plants and an egg conveyed into each slit; in other families this organ is truly a boring instrument by means of which deep holes are made into trees and eggs placed in these holes; and in still other cases the organ is fitted for thrusting an egg into the body of another insect.

Although the ovipositor is very conspicuous in many members of this suborder, there are others in which it is more or less completely concealed within the body, and thus affords but little aid to the student who is classifying his specimens; moreover, in the case of male insects we must always depend on some other character. Fortunately there is another character by which the suborders can be separated. In the Boring Hymenoptera the trochanter of the hind leg

* It is sometimes difficult, especially in the case of cabinet specimens with the wings spread, to determine whether a species is one that folds its wings or not. But we know of no other character which will always distinguish the Vespina from the Sphecina. The following will often be of service: In all North American Vespina veins V_2 and V_3 both arise from the second submarginal cell; in many of the Sphecina they do not.

is composed of two segments (Fig. 737, *b*), while in the Stinging Hymenoptera it consists of a single segment. There may be exceptions to this characterization among the minute members of the Terebrantia; but the beginning student will hardly undertake the study of these.

Family TENTHREDINIDÆ (Ten-thre-din'i-dæ).

The Saw-flies.

In this family the head and thorax are wide; the base of the abdomen is not slender, as in most Hymenoptera, but broadly joined to the thorax (Fig. 743, *j*); and the abdomen

FIG. 743.— The Locust saw-fly, *Nematus similaris*: *a*, egg; *b*, young larva; *c*, full-grown larva; *d*, anal segment of full-grown larva; *e*, cocoon; *f*, adult. (From the Author's Report for 1879.)

of the female is furnished with a pair of saws. The larvæ look like caterpillars and feed upon leaves (Fig. 743); but they have, ordinarily, from twelve to sixteen prolegs, while

true caterpillars have only ten.* Most saw-fly larvæ have the curious habit of curling the hind end of the body sidewise.

The saw-fly larvæ make parchment-like cocoons which they sometimes attach to the plants on which they have fed; but they often burrow in the ground and spin their cocoons there. The adult saw-fly lays its eggs upon the food plant, and in some strange way, perhaps by the absorption of moisture, the eggs increase in size before they hatch. The saws of the female are set side by side in a groove under the end of the body like the blades of a penknife in the handle. These saws can be shoved out and moved up and down. Here we have at least one instance where the female wielding of a saw is done most skilfully, for the female saw-fly uses these nice tools in a very efficient manner to make slits in the leaves and stems of plants in which she places her eggs.

The American Saw-fly, *Cimbex americana* (Cim′bex a-mer-i-ca′na).— This is the largest of our common saw-flies. The female is about three fourths of an inch long and has a black head and thorax, a steel-blue or purplish abdomen, with four yellowish spots on each side, smoky brown wings, and black legs, while her feet and short, knobbed antennæ are pale yellow. The male is longer and slenderer, and differs somewhat in color. The eggs are laid in June in crescent-shaped slits made in leaves. The food plants are elm, birch, linden, and willow. The larva is greenish yellow, with black spiracles and a black stripe down its back. When disturbed it spurts forth a fluid from glands just above the spiracles. There is but one brood each year. After the larva is grown it burrows in the ground, makes an oval brownish cocoon, and there spends the winter, not changing to a pupa until spring. The adult appears in May or June. These saw-flies have been known to injure willows by biting inci-

* Except in the Megalopygidæ, see p. 219.

sions half-way round the terminal twigs of the tree. What their object was in doing this is a mystery.

The Rose-Slug, *Monostegia rosæ* (Mon-os-te'gi-a ro'sæ). — Often in the summer our rose-gardens look as if fire had swept over them, so scorched and brown are the leaves. The cause of this apparent conflagration is a transparent jelly-like slug, greenish above and yellowish below, which eats the upper surface of the leaves, leaving patches of the lower surface and the veins. These slugs usually feed by night and remain hidden on the lower surface of the leaves by day. When ready to pupate they crawl down or drop to the ground and burrow beneath the surface; here each makes a little cell and then transforms. The adult fly is shining black with smoky wings, and with the fore and middle legs grayish or dirty-white. The female is about one fifth inch in length. There are two broods a year, one in June and one in August. The last brood passes the winter in the ground. This pest can be destroyed with a solution of whale-oil soap, or with kerosene emulsion.

The Pear-tree Slug, *Eriocampa cerasi* (Er-i-o-cam'pa cer'-a-si).— The eggs of this species are laid on the leaves of pear, and cherry trees, at the beginning of the summer. In about ten days the slugs hatch; they are at first whitish, but soon cover themselves with a dirty green, gummy excretion. When full-grown these larvæ attain the length of half an inch. The fore part of the body is enlarged; and they rest with their tails in the air, and appear, as Mr. Harris aptly observes, like minute tadpoles. These, like the rose-slugs, eat only the upper surface of the leaves. The species is two-brooded; the second brood passes the winter in the ground. The larvæ can be destroyed in the same way as the preceding species.

The Currant-worm, *Nematus ribesii* (Nem'a-tus ri-be'si-i). — This well-known enemy of currant and gooseberry bushes belongs to the class of criminal emigrants, and has gained a foothold and flourishes in our midst in spite of us. The fe-

male deposits her eggs on the under side of the first leaves that appear on the currant; the eggs are glossy and white, and are placed in rows along the ribs of the leaf. In ten days the larva hatches; it is at first whitish, with a big head; it grows fast, and soon becomes green, and then has black dots and a black head, and looks like a caterpillar. A brood will strip a bush of all its leaves. The larva spins a brownish paper-like cocoon, sometimes fastening it to the stripped bush, and sometimes making it just below the surface of the ground. There are two broods, and as the flies of one brood do not issue all at the same time, the fight against them must be pretty constant. Hellibore or Paris-green are the substances commonly used to destroy this insect. There is a native saw-fly on currents that has much the same habits.

Family SIRICIDÆ (Si-ric'i-dæ).

The Horn-tails.

These are so named because in this family the end of the body usually bears a spine or horn. This is short and triangular in the males, and long and often spear-shaped in the females. The horn-tails are closely related to the saw-flies, but differ from them in the shape of the ovipositor, which is made for boring instead of sawing, and in the habits of the larvæ, which are borers in solid wood.

The ovipositor consists of five long slender pieces; the two outside pieces are grooved on the inner surface, and when joined make a sheath containing the other three pieces; one of these is nearly cylindrical, and is channelled beneath for the reception of the other two, which are very slender and stiff, and furnished at the tip with transverse ridges, like the teeth of a file. With this complex instrument the female can bore a deep hole into a tree and place an egg at the bottom of it.

There are several species of horn-tails in America. A

typical species is The Pigeon Horn-tail, *Tremex columba* (Tre'mex co-lum'ba). The body of this insect is cylindrical, as large around as a medium-sized lead-pencil, and at least an inch and a half long (Fig. 744). The thorax and head are rust-red and black. The abdomen is black, with ochre-yellow bands and spots along the sides; the horn at the hind end of the body is yellow; the antennæ are rust-red, with broad black rings at the middle. The wings are smoky color and transparent; the legs are dull yellow. The female pierces the wood of a tree to the depth of half an inch, where she deposits her eggs; sometimes her ovipositor gets wedged in the wood and holds her there a prisoner until she dies. The grub is cylindrical and whitish, and attains the length of an inch and a half; it does great injury by perforating trees, especially elms. It transforms within a cocoon made of silk and fine chips. When the fly emerges it breaks through the cocoon, creeps to the mouth of the burrow, gnaws through the bark, and flies off.

FIG. 744.—*Tremex columba.*

The preceding is the only species of *Tremex* that occurs in our fauna. In this genus there is a single closed marginal and two closed submarginal cells. The Horn-tails of the genus *Sirex* (Si'rex), of which we have many species, closely resemble *Tremex* in form, but differ in having two marginal and three submarginal cells.

Family CYNIPIDÆ (Cy-nip'i-dæ).

The Gall-flies.

These insects are termed gall-flies because the majority of the species live within galls; but it should be remembered

that not all of the members of this family are developed in galls, and that galls are produced by many insects that do not belong to this family. Galls made by mites, plant-lice, flies, and moths have been described in the preceding pages, and galls are also produced by beetles and certain other insects; but the great majority of these strange growths are made either by mites, plant-lice, or true gall-flies (Cynipidæ).

The galls made by mites and plant-lice have open mouths, from which the young of the original dweller escape. But in the case of the gall-flies the gall is closed,and a hole must be made by the insect in order to emerge. Moreover, there is no reproduction of insects within the galls of gall-flies, as there is within the galls of mites and plant-lice. Many species of gall-flies undergo their transformations within their galls; while in other species the full-grown larva leaves the gall and enters the earth to transform. But in each case the adult female provides for the production of new galls, in which their young are to develop.

In the adult gall-fly the abdomen is usually much compressed. It is joined to the thorax by a short peduncle, the first abdominal segment (Fig. 745). The second and third abdominal segments are large, and the remaining segments, usually five in number, are short, and each is more or less covered by the preceding segment. Concealed within these segments is the long, partially coiled, very slender ovipositor, which arises near the base of the abdomen. The wings of gall-flies have comparatively few veins, and the fore wings lack the stigma; some forms are wingless. The antennæ are not elbowed, and consist of from thirteen to sixteen segments. The larvæ

FIG. 745.—*Amphibolips spongifica.*

are maggot-like, and without a caudal opening to the alimentary canal.

It is a remarkable fact that each species of gall-insect infests a special part of one or more particular species of plants, and the gall produced by each species of insect is of a definite form. Hence when an entomologist who has studied these insects sees a familiar gall, he knows at once what species of insect produced it.

Naturalists have speculated much as to the way galls are made to grow. It has been supposed that at the time the egg is laid there is deposited in the tissue of the plant with it a drop of poison, which causes the abnormal growth. By this theory the differences between the galls of different insects was explained by supposing that the fluid produced by each species of insect had peculiar properties. There are certain kinds of galls which may be produced in this way. Thus it is said that the wound made by a certain saw-fly in the leaves of willow causes an abundant formation of plant-cells, and the gall thus formed attains its full growth at the end of a few days, and before the larva has escaped from the egg. But with the gall-flies the gall does not begin to grow until the larva is hatched; but as soon as the larva begins to feed, the abnormal growth of the plant commences. In this case, therefore, if the gall is produced by a poison, this poison must be excreted by the larva.

There exists in many species of gall-flies an alternation of generations; that is, the individuals of one generation do not resemble their parents, but are like their grandparents. In many cases the two succeeding generations of a species differ so greatly that they have been considered not merely as distinct species, but have been placed in different genera. Thus it has been found by Mr. Adler, of Schleswig, that that while a certain species of *Neuroterus* (Neu-rot'e-rus) is developed in one kind of gall on the leaves of oak, the larvæ that hatch from eggs laid by it produce a different kind of gall, and develop into gall-flies which do not present

the characteristics of *Neuroterus*, but have been classed in another genus under the name *Spathegaster* (Spath-e-gas'ter). These in turn lay eggs which develop into gall-flies like their grandparents, i.e., a species of *Neuroterus*. Not only, says Mr. Adler, do the two generations live in galls differing in form, color, and situation, and the insects exhibit among themselves differences of size, proportions, and structure, but what renders the contrast more striking is that the Neuroterus generation is only represented by females, whilst the Spathegaster generation presents individuals of both sexes.

Although alternation of generations occurs in many species of the Cynipidæ, it is believed that there are other species in which the parthenogenetic form exists alone; that is, the species reproduce continuously without any males appearing. There can be no doubt that these parthenogenetic species have descended from species consisting of both sexes. Still, it is said that no case is now known of a bisexual form existing alone; each bisexual species is merely a link in a cycle containing a parthenogenetic generation.

The members of this family infest many kinds of plants, but their galls occur most abundantly on oaks. Among the more conspicuous species are the following:

The Fibrous Oak apple, *Amphibolips coccineæ* (Am-phib'-o-lips coc-cin'e-æ).—There are several large, spherical galls, common on oaks, which have received the name of oak-apples. These galls resemble each other quite closely in their external appearance, but differ much in their internal structure. The one which we name the Fibrous Oak-apple is represented by Figure 746. In the centre of the gall there is a small, hollow kernel, in the cavity of which the gall-fly is developed. The space between this kernel and the dense outer layer of the gall is filled with many fibres, which radiate from the kernel. This gall is found on the scarlet oak, and varies in size from three fourths inch to two inches in diameter.

The Spongy Oak-apple, *Amphibolips spongifica* (A. spon-

gif'i-ca), is most common on the red oak, but it occurs also on the black oak. In this gall the space between the kernel and the outer layer is quite densely filled with a porous mass, which suggests the name spongy.

The Larger Empty Oak-apple, *Holcaspis inanis* (Hol-cas'pis i-na'nis).—There are two oak-apples which are very similar in structure, and which may be termed the empty oak-apples. In these the space between the central kernel

FIG. 746.—Gall of *Amphibolips coccineæ.*

and the outer shell contains only a few, very slender, silky filaments, which hold the kernel in place. The larger of these two galls measures an inch or more in diameter, and is found on the scarlet oak and the red oak.

The Smaller Empty Oak-apple, *Holcaspis centricola* (H. cen-tric'o-la), is found on the post-oak, and measures three fourths of an inch or less in diameter. It also differs from the preceding in that the outer shell is mottled.

The Bullet-gall, *Holcaspis globulus* (H. glob'u-lus).—One of the most common galls on our oaks in the Northeastern

States is a bullet-like gall, which is attached to the small twigs, and which measures from one half to two thirds inch in diameter. In this gall the central kernel is surrounded by a hard, woody substance.

The Giant Oak-gall, *Andricus californicus* (An′dri-cus cal-i-for′ni-cus.—This is the most common oak-gall of the Pacific coast. It is very abundant on the twigs and branches of the California white oak, and during the winter, when the trees are bare, it is a very conspicuous object. It differs from the preceding galls in being of the type termed polythalamous; that is, instead of containing a single cell, there are several cells within it, in each of which a gall-fly is developed. This gall varies greatly in form and size; some of the larger ones measure ten or twelve inches in their greatest circumference. The outer surface of the gall is white, and usually smooth.

The Pithy Blackberry-gall, *Diastrophus nebulosus* (Di-as′-tro-phus neb-u-lo′sus), is another example of a polythalamous gall. It is a large woody growth, which occurs on the stems of blackberry. It is sometimes three inches in length and one and one-half inches in diameter. It varies in shape, but there are always several wrinkled ridges along the stem.

Fig, 747.—The Mossy Rose-gall, *Rhodites rosæ.*

The Mossy Rose-gall, *Rhodites rosæ* (Rho-di'tes ro'sæ), is a very common polythalamous gall, which is formed on the stem of the sweetbrier (Fig. 747). The gall consists of a large number of hard kernels surrounding the branch and covered with reddish or green, moss-like filaments. In each of these kernels a gall-fly is developed.

The Guest Gall-flies or Inquilines (In'qui-lins).—There are many gall-flies that do not form galls, but lay their eggs in the galls made by some other species. The larvæ of these guest gall-flies feed upon these galls, and in many instances do not discommode the owners in the least.

Family TRIGONALIDÆ (Trig-o-nal'i-dæ).

The Trigonalids (*Tri-gon'a-lids*).

This family includes only one genus, *Trigonalys* (Tri-gon'a-lys), of which there are only four North American species. All of these are rare.

In this genus there is a distinct cell between veins I and III of the fore wing; the stigma is well developed; there is only one marginal cell, but this reaches nearly to the apex of the wing; and there are four submarginal cells.

Family ICHNEUMONIDÆ (Ich-neu-mon'i-dæ).

The Ichneumon-flies.

When the discouraged farmer sees his crops harvested before due time by hordes of hungry insects, he is apt to long for a miracle to remove the plague from his fields. Oftener than he dreams the miracle takes place, and millions of insect pests never live to lay their eggs for another brood. Such miracles are most frequently wrought by members of this and the allied families. These constitute a group commonly spoken of as the Parasitic Hymenoptera (see Synopsis, p. 601), a group containing the great majority of all parasitic insects.

Very many other insects play an important part in the

destruction of insect pests; but in most cases these other insects are simply predaceous, pouncing upon and destroying such insects as they can overcome. But the true parasites act in a very different way. Although some species are external parasites, most of them live within the bodies of their victims, within which they pass their entire larval existence. Their presence in this strange situation is due to the fact that the parent lays her eggs within or upon the body of the insect to be destroyed. When the egg is laid upon the body of the victim, the larva as soon as it hatches bores its way into the body. So in either case the young parasite is in the midst of suitable food. It is probable that

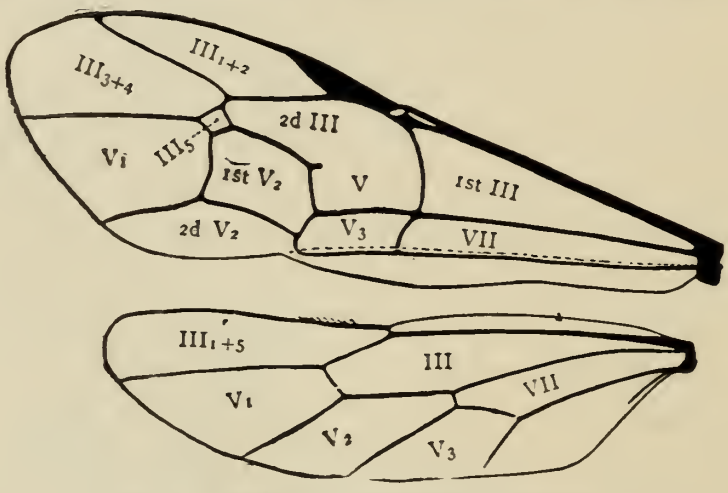

FIG. 748.—Wings of *Exetastes fascipennis*.

the parasite feeds only on the blood of its host; hence the parasitized insect is not destroyed at once, but lives on with the parasite within it, which gradually attains its growth. Finally, the parasitized insect perishes; and from the larva that has been nourished in its body there is developed a winged creature, which in turn lays its eggs in other victims. Frequently a parasitic insect lays several eggs within a single victim, so that a number of parasites may be developed within the body of a single insect. Each species of these parasites infests only certain insects, each insect having, to a great extent, its peculiar parasites.

Although the Ichneumonidæ include some minute forms,

the species are mostly of considerable size, and here belong the larger of the parasitic Hymenoptera. In this family the wings are furnished with several closed cells; the fore wings have a stigma; and cells V_1 and 1st V_2 are separate (Fig. 748).

The largest members of the family belong to the genus *Thalessa.* These are remarkable-looking insects, with long, slender bodies and three long hairs at the end of the body. Two of these hairs form a sheath for the third, which is the ovipositor. This ovipositor, although apparently merely a thread, is really composed of three pieces placed parallel, one above and two below, and securely locked together. Near the end of them are ridges like those on a file, and between them is a passage through which the egg is forced when it is laid.

Thalessa lunator (Tha-les'sa lu-na'tor) is one of the larger of our Ichneumon-flies. Its body is two and one half inches long, and it measures nearly ten inches from the tip of the antennæ to the tip of the ovipositor. It is a parasite of the wood-boring larva of the Pigeon Horn-tail. When a female finds a tree infested by this insect she selects a place which she judges is opposite a Tremex-burrow, and, elevating her long ovipositor in a loop over her back, with its tip on the bark of the tree (Fig. 749), she makes a derrick out of her body, and proceeds with great skill and precision to drill a hole into the tree. When the Tremex-burrow is reached she deposits an egg in it. The larva that hatches

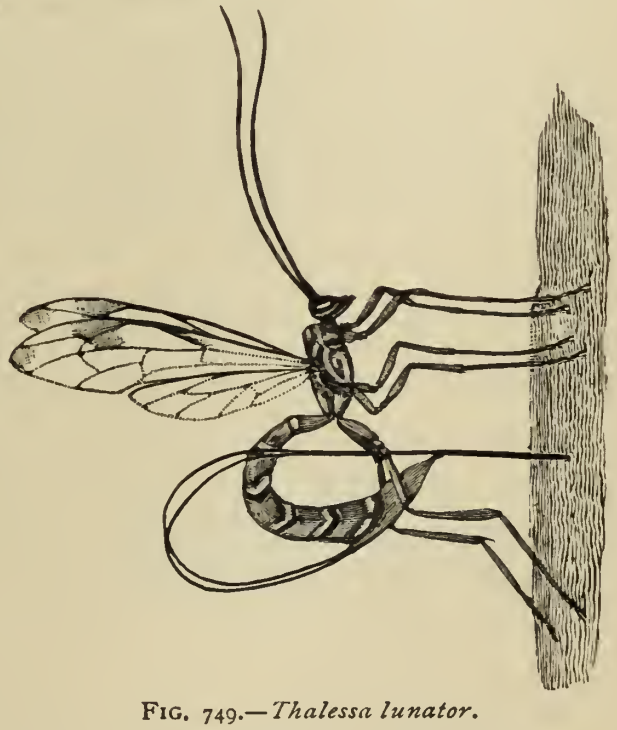

FIG. 749.—*Thalessa lunator.*

from this egg creeps along this burrow until it reaches its victim, and then fastens itself to the horn-tail larva, which it destroys by sucking its blood. The larva of *Thalessa* when full grown changes to a pupa within the burrow of its host, and the adult gnaws a hole out through the bark if it does not find a hole already made by the Tremex. Sometimes the adult *Thalessa*, like the adult *Tremex*, gets her ovipositor wedged in the wood so tightly that it holds her a prisoner until she dies.

The most common of our larger Ichneumon-flies belongs to the genus *Ophion* (O′phi-on) (Fig. 750); these have yellow bodies. They infest the caterpillars of the Polyphemus-moth, and only a single egg is laid within each victim. The caterpillar lives until it spins its cocoon, but does not change to a pupa. The Ichneumon larva when full grown spins a dense brownish cocoon within the cocoon of the caterpillar. Another smaller Ichneumon-fly, *Cryptus extrematis* (Cryp′tus ex-tre-ma′tis), infests the same caterpillar, but more than one egg is laid in a caterpillar by the female. We have bred thirty-five of these Ichneumon-flies from one caterpillar. The larvæ of this species also spin their cocoons within the cocoon of their host.

FIG. 750.—*Ophion.*

Family STEPHANIDÆ (Ste-phan′i-dæ).

The Stephanids (*Steph′a-nids*).

This family includes only four North American species, and all of these are rare. They resemble the Braconids in lacking the vein between cells V_1 and 1st V_2 of the fore wing, but differ in having a cell between veins I and III.

Family BRACONIDÆ (Bra-con'i-dæ).

The Braconids (*Brac'o-nids*).

The Braconidæ include a large number of parasites, which are small or of moderate size. They are often called Ichneumon-flies; but it seems best to restrict that name to members of the Ichneumonidæ. In the Braconids the

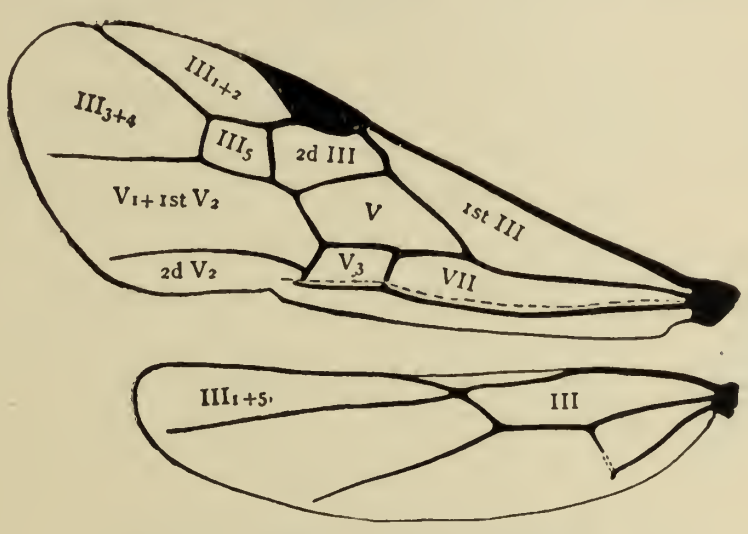

FIG. 751.—Wings of *Rhogas parasiticus.*

wings have several closed cells, the fore wings are furnished with a stigma, and the vein between cells V_1 and 1st V_2 is wanting (Fig. 751). This last character is important, as distinguishing the members of this family from the true Ichneumon-flies, which they resemble both in appearance and habits.

It is not an uncommon thing, especially in vineyards, to find a feeble caterpillar with its back covered with little, white, oblong bodies, which the ignorant usually think are its own eggs (Fig. 752). These are the cocoons of braconid parasites. The larvæ obtain their growth within the body of the caterpillar, and just before it perishes they leave it, and spin their silken cocoons upon its back. When these cocoons are examined with a lens they are found to be beau-

FIG. 752.—Caterpillar with cocoons of a Braconid.

tiful objects, resembling in miniature those of the silkworm. The adult parasite in emerging from its cocoon cuts a neat little lid at its upper end. These parasites belong to the genus *Microgaster* (Mic-ro-gas'ter). Bunches of white or yellow cocoons of *Microgaster* are often found attached to grass or other plants instead of to the back of the caterpillar which the larvæ have destroyed (Fig. 753).

FIG. 753.

Perhaps the most interesting of the common forms belonging to this family are those belonging to the genus *Aphidius* (A-phid'i-us). The members of this genus are minute creatures which infest plant-lice. If colonies of Aphides be examined, the dried bodies of dead ones may be found in which the abdomen is more or less spherical, being greatly distended. These bodies remain clinging to the leaves in the position in which the insects were when they died. From each one there emerges in due time an *Aphidius*. The parasite in emerging cuts a very regular circular lid in the dorsal wall of the abdomen of its host (Fig. 754). We have watched with much interest these little Braconids ovipositing in the bodies of plant-lice. When one has selected a plant-louse in which to oviposit she stands with her head towards it, and bending her abdomen under her thorax between her legs she darts her ovipositor forward into the body of the Aphis. The species of this genus do not construct cocoons, but undergo their metamorphoses within the dried skins of the plant-lice.

FIG. 754.

Family EVANIIDÆ (Ev-a-ni'i-dæ).

The Ensign-flies.

This is a small family, comprising insects of very peculiar structure. They can be easily distinguished by the fact

that the abdomen is attached to the top of the metathorax, and not at the hind end of it, as with other insects. The abdomen is compressed, and has a very slender base.

The venation of the wings also presents a striking peculiarity. In other Hymenoptera vein V of the fore wings

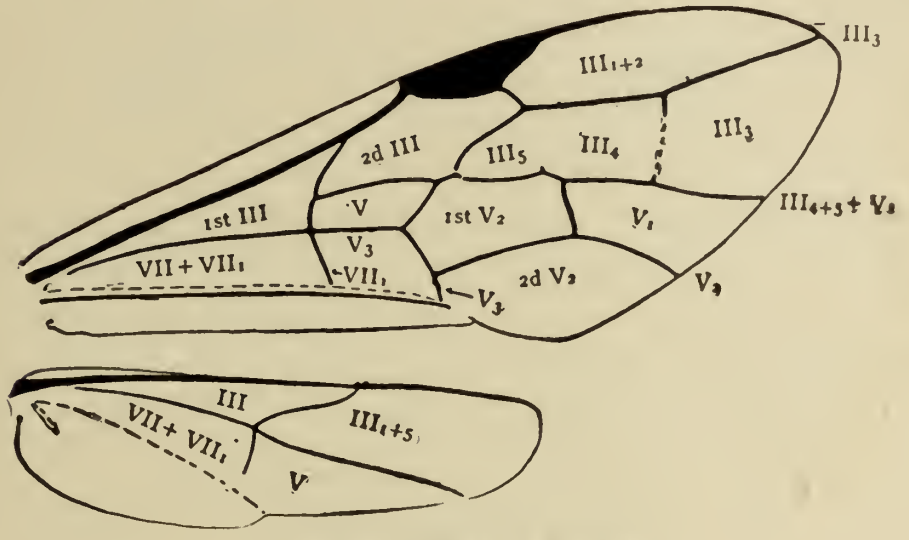

FIG. 755.—Wings of *Aulacus*.

arises from some point on the cross-vein III–VII that is nearer to vein III than to vein VII, while in the Evaniidæ the origin of vein V is nearer to vein VII than to vein III.

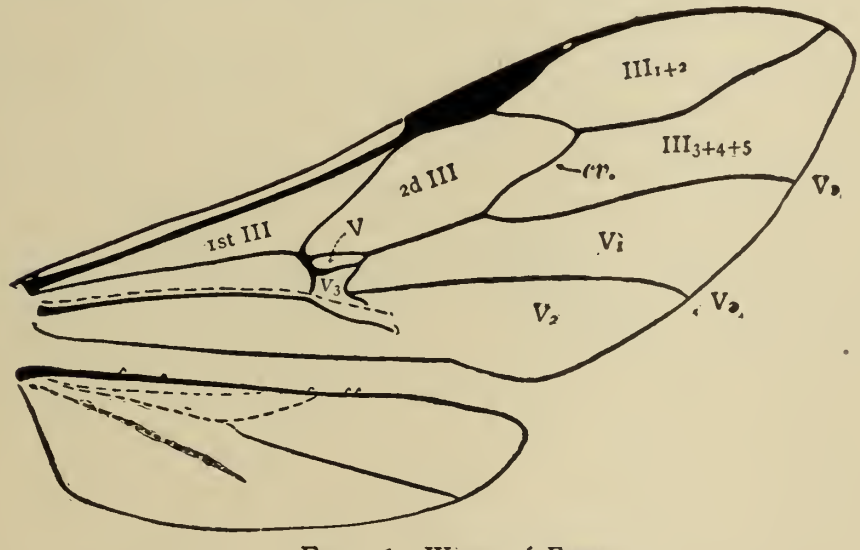

FIG. 756.—Wings of *Fœnus*.

In the more generalized members of the family, as *Aulacus* (Au'la-cus), the origin of vein V is but a little way from the

middle of cross-vein III–VII (Fig. 755); but in *Fœnus* (Fœ'nus) (Fig. 756) vein V has migrated so far toward the anal furrow that it no longer arises from the cross vein, and cell V is reduced to a mere areolet.

These insects are parasitic; we have bred one species,

FIG. 757.—*Evania appendigaster.*

FIG. 758.—*Fœnus.*

Evania appendigaster (E-van'i-a ap-pen-di-gas'ter) (Fig. 757), from the oötheca of a cockroach, and have found another, a species of *Fœnus* (Fœ'nus) (Fig. 758), common on flowers.

We have named these insects Ensign-flies, because they carry the abdomen aloft like a flag.

Family CHALCIDIDÆ (Chal-cid'i-dæ).

The Chalcis-flies.

The Chalcis-flies are among the smaller of the parasitic Hymenoptera. In fact they are usually minute insects, often not more than one one-hundredth of an inch in length; on the other hand, a few of our species are much larger, a common one measuring three eighths of an inch in length. They are nearly always black, with strong metallic reflec-

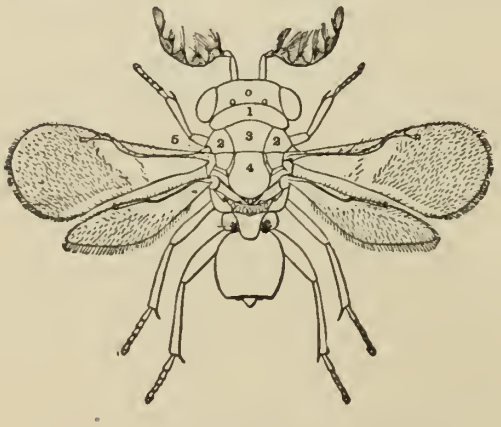

FIG. 759.—*Dilophogaster californica.*

FIG. 760.—*Aphycus eruptor.*

tions, although some species are yellow. The head is usually large; the prothorax does not extend back on each

side to the cup-like scale covering the base of the fore wing; the wings have no closed cells; and the ovipositor is usually hidden, issuing before the apex of the abdomen. Figures 759 and 760 represent Chalcis-flies greatly enlarged.

It is to this family that the great majority of the parasites of the smaller insects belong. Thus scale-bugs are preyed upon by many species of Chalcis-flies. But Chalcis-flies also attack large insects, for many caterpillars are destroyed by them. The most efficient parasite of the cabbage-butterfly is a Chalcis-fly, *Pteromalus puparum* (Pterom'a-lus pu-pa'rum). In the case of these larger insects hundreds of Chalcis-flies may reach maturity within a single individual.

The larvæ of Chalcis-flies usually feed within their victims, but a few live attached externally. Some Chalcis-flies, like the members of the next family, are egg-parasites, and certain others are developed within the galls produced by members of other families (Cynipidæ and Cecidomyidæ), and are doubtless merely inquilines, instead of parasites.

The members of one subfamily closely approach the gall-flies (Cynipidæ) in structure and in habits. One of these, the Joint-worm, *Isosoma hordei* (Is-o-so'ma hor'de-i), is a well-known pest, which infests the stalks of growing grain. It causes a woody growth, which fills up the cavity of the stalk, and sometimes also causes a joint to swell and the stalk to bend and lop down. The presence of this insect is often indicated by pieces of hardened straw coming from the threshing-machine with the grain. There is but a single generation of the joint-worm in a year. The insects remain in the straw during the winter, the adults emerging in the spring. Obviously the best way to destroy this pest is to burn the infested straw before the insects emerge.

The Chalcis-flies of the genus *Leucospis* (Leu-cos'pis) are very remarkable in form. They agree with the true wasps, and differ from all other Hymenoptera in having the fore wings folded like a fan when at rest. They are also peculiar in

having the ovipositor of the female curved up over the dorsum of the abdomen to the thorax. Our most common species is *Leucospis affinis* (L. af-fi'nis); this measures about three eighths inch in length.

Family PROCTOTRUPIDÆ (Proc-to-tru'pi-dæ).

The Proctotrupids (Proc-to-tru'pids).

These insects, in spite of their long family name, are the smallest of the parasitic Hymenoptera; and in fact the smallest of all known insects belongs to this family. The larger species rarely exceed one twenty-fifth of an inch in length; the smallest, *Alaptus excisus* (A-lap'tus ex-ci'sus), measures between six and seven one-thousandths of an inch.

FIG. 761.

In shape, the body is slender, and the color is almost invariably black or brown without metallic lustre; the prothorax extends back on each side to the cup-like scale covering the base of the fore wing; the wings are often wanting, and when present are entirely veinless, or they may approach the venation of some of the Chalcis-flies, or in other cases that of some of the Braconidæ; the ovipositor issues from the apex of the abdomen. Figure 761 represents a Proctotrupid greatly enlarged.

The Proctotrupids are nearly all parasitic; and very many of them infest the eggs of other insects. The female Proctotrupid bores a hole with her ovipositor through the shell of an egg of one of the larger insects, and deposits one of her eggs inside of it. Here the young parasite when it hatches finds itself in the midst of food which is sufficient for it till it is fully grown. The transformations are passed within the infested egg, from which the parasite comes forth an adult. Other species are internal parasites of larvæ, and some are secondary parasites, that is, parasites upon

other parasites. A few species are inquilines, but none have been found to be injurious to vegetation.

Suborder ACULEATA (A-cu-le-a'ta).

The Stinging Hymenoptera.

In the second of the two suborders into which the Hymenoptera are divided we find at the caudal end of the body of the female a sting connected with a poison gland, the well-known organ of offence of these insects. This is really the same organ as that which we have termed the borer in the first suborder, but its form and use are different. It should be said, however, that the sting of insects of this suborder is not a simple spear, as often supposed, but is really a compound organ composed of essentially the same parts as the borer described in preceding pages. In some cases the sting is imperfectly developed: thus we find that while certain ants have well-developed stings, others are not able to sting at all.

In the Aculeata, as already indicated on page 610, the trochanter of the posterior legs consists of a single segment (Fig. 737, *a*, *c*).

In the adult insects of this suborder the abdomen consists of six complete segments in the female, and seven in the male. This character is very useful in separating the sexes of these insects.*

Family PELECINIDÆ (Pel-e-cin'i-dæ).

The Pelecinus (*Pel-e-ci'nus*).

This family is represented by a single species, *Pelecinus polyturator* (P. pol-y-tu-ra'tor), which is a very remarkable insect. The females are common where they occur, and are easily recognized by the slender and very long abdomen (Fig. 762). The abdomen of the male is club-shaped, and

* No account is taken here of the propodeum (see page 602).

only about twice the length of the head and thorax. This sex is very rare; it can be recognized by the venation of the wings, which is similar to that of the female. Nothing

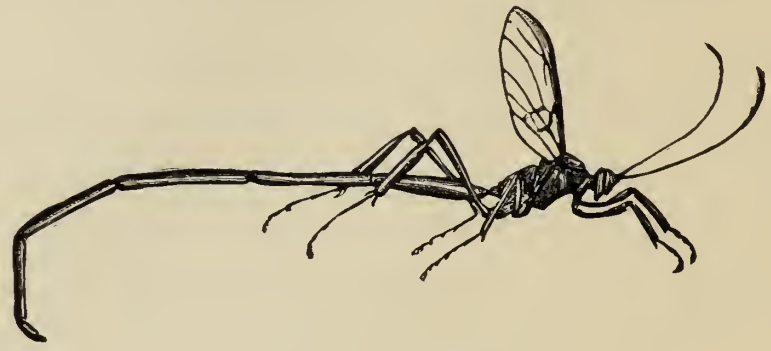

FIG. 762.—*Pelecinus polyturator*, female.

is known regarding the habits of this species, but it is supposed to be parasitic, like the Ichneumon-flies.

Family CHRYSIDIDÆ (Chry-sid'i-dæ).

The Cuckoo-flies.

The cuckoo-flies are wonderfully beautiful creatures, being usually a brilliant metallic green in color. The species are of moderate size, the largest being only about a half inch in length. They can be distinguished from other Hymenoptera by the form of the abdomen, in which there are only three or four visible segments (Fig. 763), except in the male of a single genus (*Cleptes*), where there are five. The abdomen is convex above and flat or concave below, so that it can be readily turned under the thorax and closely applied to it. In this way a cuckoo-fly rolls itself into a ball when attacked, leaving only its wings exposed.

FIG. 763.—*Chrysis nitidula.*

Although these insects are handsome, they have very ugly morals, resembling those of the bird whose name has been applied to them. A cuckoo-fly seeks until it finds one of the digger-wasps, or a solitary true wasp, or a solitary

bee, building a nest, and when the owner of the nest is off collecting provisions steals in and lays its egg, which the unconscious owner walls in with her own egg. Sometimes the cuckoo-fly larva eats the rightful occupant of the nest, and sometimes starves it by eating up the food provided for it. The bees and wasps know this foe very well, and tender it so warm a reception that the brilliant-coated little rascal has reason enough to double itself up so that the righteous sting of its assailant can find no hole in its armor. There is one instance on record where an outraged wasp, unable to sting one of the cuckoo-flies to death, gnawed off her wings and pitched her out on the ground. But the undaunted invader waited until the wasp departed for provisions, and then crawled up the post and laid her egg in the nest before she died.

Some of the cuckoo-flies are true parasites; one of them infests the currant-worm in Europe. It is to be hoped that this species will find its way to this country.

Superfamily FORMICINA (For-mi-ci'na).

The Ants.

The ants are easily recognized by the well-known form of the body. The only insects that are liable to be mistaken for ants are the white-ants or Termites (*Termitidæ*) and the velvet-ants (*Mutillidæ*). But the true ants are readily distinguished from these and other insects by the form of the abdomen. With the ants the first segment of the abdomen, and in one family the second also, forms a lens-shaped scale or knot, varying in form and serving as a peduncle to the remaining portion of this region of the body (Fig. 764). The winged ants are also peculiar in lacking the cup-like scale or tegula at the base of each fore wing.

FIG. 764.

If the statesman or the philosopher would study a perfect communistic society, let him throw away his histories

of poor human attempts, and go and study thoroughly the nearest ant-hill. There he will find no love for friend or wife or child, but a love for every one. There everything is done for the good of the whole, and nothing for the individual. The state makes wars, provides food for all, cares for the children, owns all the property. He will find no complaint against the existing condition of society, no rebels; but the fate of each one is determined by the accident of birth, and each takes up its work without a murmur. He will find that this perfect commune has developed courage, patriotism, loyalty, and never-failing industry; but he will find also that war, pillage, slavery, and an utter disregard of the rights of other communities and individuals are as prevalent as they are among our own nations, where selfish private ambition has held sway so long.

There are always three classes of ants in a colony: males, females, and workers. The males and the females are winged, the workers wingless. Often in warm summer afternoons the air will seem to be filled with countless thousands of flying ants. Their moving wings divide the sun's rays into rainbow flashes as they rise or fall, a silent, onward-moving host. This is the wedding-journey of the male and female ants, which have come from many communities and have taken flight together. But soon the journey is over and they drop to earth, where the males soon die; but the females tear off their own wings, having no further use for them, and set about to find places to lay their eggs. Sometimes a female starts a new colony; in other cases she is found by some workers of her own species and adopted as their queen.

Comparatively little is known regarding the formation of new colonies of ants. It has been a question whether a colony is founded by a single queen working alone, as with the bumblebees and social wasps; or whether a queen associates a number of workers with herself and they together found the colony, as with the Honey-bee. The writer has

demonstrated by repeated experiments that in the case of our common carpenter-ant (*Camponotus pennsylvanicus*) the former method is practised. But it is not improbable that with certain other species the latter method occurs.

On many occasions we have found a queen of the carpenter-ant in a small cleared space beneath the bark of a dead tree or log. Some of these queens were alone; others were accompanied either by eggs, larvæ, or by small workers, On one occasion we collected several such queens and placed each with her eggs in a cell between plates of glass in an artificial ant's nest, and have thus watched the beginnings of colonies. A few eggs, from ten to fifteen, are laid at first; these soon hatch, and the larvæ develop quite rapidly. A nest which on July 15th contained, besides the queen, only seven eggs, contained July 27th thirteen eggs, three larvæ, and one cocoon; and on Aug. 14th there were six cocoons. In another nest, which on July 15th contained, besides the queen, only young larvæ, the larvæ began to spin cocoons on July 19th, and on Aug. 8th the workers began to emerge. On Aug. 16th the workers had begun to work, carrying the empty cocoons out of the nest, and on Aug. 20th the workers began to take into the nest dead flies that had been placed at the entrance.

The most remarkable result of this experiment was the demonstration of the fact that from the time the queen forms her cell and begins to lay eggs to the time when a brood of workers is matured no food is taken into the nest. The cell is a closed one, and contains no store of food except what may be within the body of the queen. The queen does not leave the nest; and when we placed food within a nest the queen built a wall of earth about it, thus walling it out.

To test this matter a queen was placed with some of her eggs in an empty vial, and Swiss muslin was tied over the mouth of it. Here, where the queen could not possibly obtain food, the larvæ matured, spun cocoons, and adult workers emerged. The queen was often seen to apparently

lick the workers, and the conclusion was forced upon us that there was stored up within the stomach of the queen a supply of food, which was regurgitated and fed to the larvæ. It should be noted that this first brood of workers consists of very small individuals, of the type known as worker-minor.

The term queen, as applied to the individual at the head of a colony of ants, is a misnomer, for among social insects the queens do not rule ; they are merely the mothers of their colonies. The queen ant is not jealous, like the queen bee, but may live in peace in the same dwelling with several other queens. She is always an object of extreme devotion to her attendants, who feed her and care for her eggs as soon as she lays them.

The larvæ of ants are white and legless; most species spin cocoons when ready to pupate, but some do not. The oblong, egg-shaped bodies, which may be seen in any ant's nest, and which are often mistaken by the careless observer for eggs, are these cocoons. The eggs are so small that they escape observation unless careful search is made for them. The larvæ are efficiently cared for by the workers, who carry them about and put them in the warmer parts of the nest and feed them. When the adults issue from the cocoons their nurses help them out carefully ; and they unfold the legs and smooth out the wings of new-fledged royalty with tenderest solicitude. The workers are by far the most interesting portion of the ant colony, as they do all the work, feed the colony, build and defend the nests, care for the young and for the stock, and carry on the wars. The workers are undeveloped females, which very rarely lay eggs, and as the eggs of workers always develop into males, the presence of a queen is necessary for the perpetuation of the life of a colony. For this reason, as the queens grow old the workers find young queens at the swarming season, bring them into their nests, and adopt them as successors to the old queens.

There are many forms of ants' nests, but each species builds the same sort. Sometimes the nest is a simple tunnel in the earth, sometimes a large mound with tunnels and galleries extending many feet under ground; and some species live in decayed trees. In the tropics a greater variety of these structures occur than in our country. Some colonies own several mounds. One colony of one species has been known to have two hundred mounds, covering several hundred square yards. Ants are also very good road-makers, sometimes making clean, beaten paths, and sometimes working out covered ways under rubbish.

As to their food, ants are general feeders, eating animal food and also sweet substances, like the juice of fruit and sugar; and they are also very fond of the honey-dew given off by Aphids; and the ants regard these Aphids as their milch-cows. An ant will walk up to an Aphid and stroke its back with its antennæ, and immediately the pleased Aphid gives forth a drop of sweet fluid, which the ant at once drinks up. The ants take very good care of their cattle, and will carry them to new pastures if the old ones dry up. They also carry the Aphid-eggs into their nests, and keep them sheltered during the winter, and then carry the young plant-lice out and put them on plants in the spring. When ants are seen going up and down the trunks of trees it is safe to suppose they are attending Aphids. They also care similarly for some of the Coccids (especially some Lecaniums) and a few other honey-giving insects (Tree-hoppers and others).

Many species of beetles are also found in ants' nests, but the ants have never revealed to us why these insects are allowed to dwell in peace in their habitations.

We have many evidences that ants think, but what goes on in their minds we can only guess. They have a language that seems to exist through the sense of touch. The antennæ are most sensitive organs, and when ants meet they cross their antennæ and pat each other. If one finds some

large article of food, too heavy for it to carry, it goes for aid, and the first fellow it meets it pats with its antennæ, and the two start off together for the booty. If a nest is attacked the workers or soldiers rush around and stroke each other with their antennæ, and thus evidently give warning and plan a battle for protection. In case an ant finds a comrade in distress it shows great solicitude and activity in giving relief. Yet there are some species that, like the Spartans, kill off the feeble and old, as useless to the colony. When a portion of a colony is removed and kept imprisoned for a time, and then returned, there is great rejoicing on both sides. Gould says they have a way of standing on their hind legs and prancing around under such circumstances, as well as when they enter the cell of their queen, that indicates great joy. Sometimes they get to be very hilarious and wrestle with each other, and carry each other around as if it were a part of a game that they found amusing—a sort of formic football.

But it is in their wars that the ants show that they are trained athletes. They do most of their fighting with their jaws, but they also eject upon each other an acrid fluid called formic acid. They are very courageous, and will attack a man as readily as a grasshopper. They seem in a great rage when they fight, and are fierce beyond belief. After a battle the field is strewn with legs, heads, and bodies. They usually wage war against other species, but sometimes two colonies of the same species will go to war if their nests happen to encroach upon each other. When an army is ready to go forth for conquest, scouts are sent out and the army waits till they return before it starts. Very often these armies go forth to capture slaves, for there are several species of ants that are slaveholders, and by strange coincidence the slaves are dark colored, while the masters are light. When a depredating army sets forth it proceeds to the black colony, which defends itself fiercely; if the besieged blacks are overcome, the conquerors carry off all the

larvæ and pupæ to their own nests, and bring them up with their own, and they in turn work hard for their captors, and take great interest in their welfare and success. When a party of marauders comes back without any booty their slaves give them a cold reception; but if they come back laden with plenty of larvæ and pupæ, the slaves rush out and meet them with apparent delight and exultation.

Some species of slaveholders (e.g., *Formica difficilis*) work side by side with their slaves. However, in one species (*Polyergus rufescens* of Europe) the masters have depended upon their slaves so long that they cannot build their own nests or feed themselves or care for their young, but have only retained the power of fighting to get more slaves. Hüber tells of placing several of these slaveholders by themselves, where nearly all helplessly starved, although there was plenty of food all around them. Then a slave was introduced, which at once set to work and made a nest and fed those still alive, thus saving from death its stupid masters.

The classification of the ants is still in a very imperfect state. Many of our common species are still undescribed, and the limits of the families have not yet been determined. But, if we except a few species found in Texas and Utah, our described species represent only three families. These can be separated by the following table: —

TABLE OF FAMILIES OF THE FORMICINA.

A. Peduncle of the abdomen consisting of a single segment.
  B. Abdomen not constricted between the second and third segments (the first segment forms the peduncle). p. 640. FORMICIDÆ.
  BB. Abdomen constricted between the second and third segments. p. 642. PONERIDÆ.
AA. Peduncle of the abdomen consisting of two segments. p. 642. MYRMICIDÆ.

Family FORMICIDÆ (For-mic'i-dæ).

The Typical Ants.

The ants of this family can be recognized by the following characteristics: the peduncle of the abdomen consists of a single segment; there is no constriction between the second and third abdominal segments (Fig. 765); and the queens and workers have no sting. The pupæ are sometimes contained in a cocoon and are sometimes naked. The following are some of our more common species:

FIG. 765.—A Formicid.

The Carpenter-ant, *Camponotus pennsylvanicus* (Cam-po-no'tus penn-syl-va'ni-cus).—This is one of the largest of our common ants. Its entire body is black. It builds its nests in the timbers of buildings, in logs, and in the trunks of trees. Frequently they build in the dead interior of a living tree, excavating a complicated series of chambers. The way in which new colonies of this ant are founded is described on page 635.

The Mound-building Ant, *Formica exsectoides* (For'mi-ca ex-sec-toi'des).—This species is the builder of our largest ant-hills; these are often five or six feet across, and sometimes more than twice that in diameter. The head and thorax of this ant are rust-red, while the legs and abdomen are blackish brown. This species has been supposed to be the same as the European Wood-ant, *Formica rufa*, and is referred to in many books under that name.

The Slavemaker-ant, *Formica difficilis* (F. dif-fic'i-lis).—One of our common slave-making ants is this species. It very closely resembles the preceding in size and in color; in fact it is difficult to distinguish the two apart without the use of a microscope. The Slavemaker-ant usually makes its nest almost entirely underground. We often find these

nests beneath large flat stones. It is a curious fact that in a single nest some of the pupæ will be enclosed in cocoons while others are naked. This ant is not always accompanied by slaves; but it is a common occurrence to find its dark-colored associate with it. The way in which this ant gets its slaves has been described above (p. 638).

The Slave-ant, *Formica subsericea* (F. sub-se-ric'e-a).—This is usually a dark-brown or ash-colored ant with reddish legs, but it varies greatly in color. It generally makes its nest in the ground, beneath a stone or other object, and leads an independent life when allowed to do so. But it is this species that *Formica difficilis* enslaves.

The Corn-louse Ant, *Lasius brunneus* (Las'i-us brun'ne-us).—This is the common, brown, small ant, about one eighth inch in length, whose nests abound along the borders of roads, in pastures, and in meadows. It is an exceedingly interesting species on account of the care it is known to take of certain plant-lice that feed upon the roots of grass and of grain. One of these plant-lice feeds on the roots of corn, and is a very serious pest in the middle West. It has been discovered that this ant cares for the eggs of this plant-louse, keeping them in its nest during the winter, thus making sure of having a herd of Aphids from which it can get a supply of honey-dew the following summer.

The marriage flights of the ants of the genus *Lasius* are remarkable. The nests of these ants are so inconspicuous that they are rarely observed except when search is made for them. But the males and young queens from all the nests in one region will emerge at one time, usually some warm afternoon, and, where a short time before no ants could be seen, the air becomes filled with these flying creatures. We have ridden for several miles through such a swarm, when the ants were so abundant that it was almost impossible to breathe without inhaling them. The ants that make up these swarms are very different from the workers that we find in the nests. Both the young queens and the

males are winged, and the queens are much larger than either the workers or males.

The Honey-ant, *Myrmecocystus melliger* (Myr-mec-o-cys'-tus mel'li-ger).—This ant exhibits a striking peculiarity. One form of the workers has its abdomen enlarged to the size of a currant and filled with honey (Fig. 766). This species lives in high altitudes in the southwestern part of our country, and builds nests in the form of little mounds. The honey-bearing individuals are found clinging to the roofs of their chambers, and are merely storing vats for a sort of honey which the other workers collect from galls that grow on oak-trees and feed to them. When the season for obtaining this food is past, these living cells disgorge their supply through their mouths for the use of their hungry fellows.

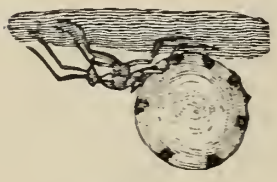

FIG. 766.

Family PONERIDÆ (Po-ner'i-dæ).

The Ponerids (*Po-ne'rids*).

The ants of this family resemble those of the preceding family in that the peduncle of the abdomen consists of a single segment, but differ in having the abdomen constricted between the second and third abdominal segments (Fig. 767), and in the possession of a sting by the queens and workers. The pupa state is passed within the cocoon. But few species belonging to this family have been described in this country, and most of them are rare. Their favorite nesting-place is beneath stones.

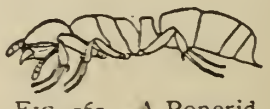

FIG. 767.—A Ponerid.

Family MYRMICIDÆ (Myr-mic'i-dæ).

The Myrmicids (*Myr-mi'cids*).

The ants of this family are easily recognized by the fact that with them the peduncle of the abdomen consists of two

segments (Fig. 768). The queens and workers are armed with a sting, and the pupæ are naked. The following will serve to illustrate this family:

FIG 768.—A Myrmicid: *a*, antenna-cleaner at the base of the tarsus of the front leg, enlarged.

The Red-ant, *Monomorium pharaonis* (Mon-o-mo'ri-um phar a-o'nis).—The most troublesome of all ants that live in this country is a minute yellow species that frequently invades houses. Although this species is light yellow in color, it is commonly known as the Red-ant. When these ants build their nests within the walls or beneath the foundations of a house it is almost impossible to dislodge them. By trapping and destroying the workers their numbers can be lessened somewhat. But so long as the queens are undisturbed in their nests the supply of workers will continue.

The Shed-builder Ant, *Cremastogaster lineolata* (Cre-mas-to-gas'ter lin-e-o-la'ta).—This is a small ant, the workers measuring from one eighth to three sixteenths inch in length. It is usually yellowish brown, with a black abdomen; but it varies greatly in color. Its favorite nesting-place is under stones or underneath and within the decayed matter of old logs and stumps. Out of this material the ants sometimes make a paper-like pulp with which they build a nest attached to the side of a log, or even to the branches of a shrub at some distance from the ground. Professor Atkinson describes such a nest,* which was built several feet from the ground, on a bush, and was eighteen inches long and twelve inches in circumference; it contained about one fourth pint of adults, pupæ, and larvæ, and was doubtless the home of the colony. But these ants often build small sheds, at some distance from the nest, over the herds of Aphids or scale-insects from which they obtain honey-dew. In these

*American Naturalist, Aug. 1887.

cases the Aphids or scale-insects are huddled together on a branch, from which they are deriving their nourishment, and are completely covered by the "cow-shed" built by the ants.

Superfamily SPHECINA (Sphe-ci'na).

The Fossores (Fos-so'res) or Digger-wasps.

There are several closely allied families of the Hymenoptera that are usually classed together as the Fossores or Digger-wasps. These names refer to the fact that most of these insects make nests for their young by digging burrows in the ground or in wood. Many true wasps and bees have similar habits, but these insects differ in appearance from the Fossores in the following easily seen characteristics: The true wasps when at rest have their wings folded like fans, while the digger-wasps have their wings lying flat above the body. The bees have the basal segment of the tarsi of the hind legs flattened for carrying pollen, while the digger-wasps have legs fitted only for digging and walking.

The Fossores are all solitary in their habits, that is, each female makes provision for her young. The adults are very fond of the warm sunshine, and may be seen flitting about flowers in the tropical heat of the noontide. As in most Hymenoptera, the male dies early, leaving the entire work of the nest-building and family cares to the female; however, she seems entirely equal to her responsibilities. She burrows in the ground or in wood, or utilizes the forsaken burrows of other species, or builds in the ready-made cavities of reeds or straws, or constructs a tube out of mud. The nest thus made is provisioned with spiders or with insects, which are not killed, but stung until paralyzed. The prey thus treated remains alive a long time, but is helpless. The egg is laid with this provision, and then the opening of the tube sealed up securely. When the larva hatches it finds nicely preserved food right at hand sufficient to nourish it during its growth.

As a rule, each species provisions its nest with a particular kind of food. Some use only spiders for this purpose, some plant-lice, some caterpillars; and so on through the list.

Very interesting and useful work can be done by the student in the study of the habits of the digger-wasps and of the solitary true wasps and solitary bees. Comparatively few nests of either of these groups of insects have been carefully described in this country; and as each species presents peculiarities of habits, the study is a very fascinating one.

The nests are most abundant in sandy banks and in the pith of sumach, elder, brambles, and other plants. Some nests are dug in the earth in level places, and many are built of mud and attached to the lower surface of stones or beneath the roofs of buildings.

The nests made of mud should be carefully removed so as not to break them, the nature of the provisions noted, and the nest placed in a cage to breed the adult. When the adult has been obtained, both nest and insect should be mounted and placed in a collection.

In many cases the cells of mining species can be removed from the earth and the insects bred in a similar way. But the easiest nests to study are those made in the pith of plants. If dead branches of sumach or elder be split open many of these insects can be found. If the branch be split carefully the peculiarities of the nest can be observed without injury to its occupants. Then if the pieces of the branch be tied together the adult insects can be bred by placing the nest in a glass jar or other cage, or in a bag of muslin, if the branch is a long one.

If a nest is provisioned with a paste made of pollen and nectar, it is a nest of a bee; but if it is provisioned with spiders or insects, it belongs either to a digger-wasp or to a solitary true wasp. We know of no way of distinguishing between the nests of the last two except by breeding the adults.

In breeding these insects from their nests care should be taken not to mistake cuckoo-flies or other guest-insects or parasites for the rightful owners of the nests. The fact that members of each of these classes of insects are common in these nests adds both to the complexity and interest of the study.

The digger-wasps found in America north of Mexico represent fourteen families. These can be separated by the following table:

TABLE FOR DETERMINING THE FAMILIES OF THE SPHECINA.*

A. Pronotum considerably produced backward on the sides reaching the tegulæ in the winged forms; in one family the females are wingless.

B. Abdomen with the first ventral abdominal segment distinctly separated from the second by a constriction (Figs. 769, 770).

C. Intermediate tibiæ with two apical spurs; the intermediate coxæ contiguous, or but little separated; females wingless. p. 648 ..... MUTILLIDÆ.

CC. Intermediate tibiæ usually with a single apical spur, very rarely with two; intermediate coxæ, as a rule, widely separated; both sexes winged. p. 649 ..... SCOLIIDÆ.

BB. First and second ventral abdominal segments not separated by a constriction.

C. Hind legs short, the tibiæ not reaching to the apex of the abdomen. p. 649 ..... SAPYGIDÆ.

CC. Hind legs long, the tibiæ reaching beyond the apex of the abdomen. p. 650 ..... POMPILIDÆ.

AA. Prothorax usually consisting of little more than a narrow collar, the posterior angles not reaching the tegulæ; both sexes winged in all species.

B. Fore wings with three closed submarginal cells, (Fig. 773, 2d III, III_5, III_4).

C. Base of abdomen with a long slender portion (petiolate).

* This table is based on one given by Mr. Cresson in his Synopsis of the Hymenoptera of America north of Mexico, Philadelphia, Am. Ent. Soc., 1887.

D. Vein V_3 arising at or beyond the end of the 2d cell III (Fig. 773).*

E. Petiole of abdomen cylindrical, smooth; antennæ slender at apex; tibiæ of middle legs with two apical spurs. p. 650. SPHECIDÆ.

EE. Petiole of abdomen depressed and generally furrowed above; antennæ thickened at apex; middle tibiæ with one apical spur. p. 655 ..... MIMESIDÆ.

DD. Vein V_3 arising before the end of the 2d cell III. MELLINIDÆ.†

CC. Base of abdomen without a long, slender portion (not petiolate).

D. Veins V_2 and V_3 arising from the second submarginal cell (III_5) (Fig. 775); sometimes vein V_2 arises from the end of cell III_5.

E. Fore wings with an appendiculate cell (Fig. 775, *ap.*); mandibles usually more or less deeply notched on the exterior margin. p. 652 ..... LARRIDÆ.

EE. Appendiculate cell wanting; mandibles with the exterior margin entire.

F. Labrum short, projecting but little, if at all. p. 654. NYSSONIDÆ.

FF. Labrum distinctly exserted, sometimes forming a long triangular beak (Figs. 776, 777) 652 ..... BEMBECIDÆ.

DD. Vein V_2 arising from cell III_4 and vein V_3 from cell III_5 (Fig. 779). p. 654 ..... PHILANTHIDÆ.

BB. Fore wings with two closed submarginal cells (Fig. 781, 2d III + III_5 and III_4).

C. Prothorax long and narrow, produced anteriorly into a neck. (As this family includes only a single American species, and that a very rare one, it is not discussed in this work.) AMPULICIDÆ.

CC. Prothorax short, transverse. p. 655 ..... PEMPHREDONIDÆ.

BBB. Fore wings with only one closed submarginal cell (Fig. 783, 2d III + III_5). p. 656 ..... CRABRONIDÆ.

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* Vein V_3 is the vein between cells V and 1st V_2, and between cells V_3 and 1st V_2. In the species represented in Figure 773 it arises near the middle of cell III_5 and extends backward for more than half its length.

† This family includes only two species found in the Rocky Mountain region, and a single, very rare, one found in the Eastern States. It is not discussed in this work.

Family MUTILLIDÆ (Mu-til'li-dæ).

The Velvet-ants.

These handsome insects resemble ants in the general form of the body, but lack the scale-like knot of the peduncle of the abdomen characteristic of those insects, although there is a constriction between the first and second abdominal segments (Fig. 769). The body is densely covered with hair, which gives the insects the appearance of being clothed in velvet; and as the body is usually ringed with two or more strongly contrasting colors, they are very conspicuous. The colors most commonly worn by the velvet-ants are black and scarlet. The males are winged and frequent flowers. The females are wingless; but they run very fast, and can sting severely.

FIG. 769.

These insects are abundant in the warmer portions of our country; our lists now include one hundred and sixty North American species. The largest of these and a very common species is *Sphærophthalma occidentalis* (Sphær-oph-thal'ma oc-ci-den-ta'lis). This species measures from two-thirds of an inch to a little more than an inch in length; it varies in color, but is usually black and scarlet. It is known to dig burrows in beaten paths and store in them flies and other insects. It will also enter bee-hives and kill and eat bees. In Texas it is known as the Cow-killer ant, because of a popular superstition that its sting is very dangerous to live stock.

Several exotic species of Mutilla live in nests of bumble bees; but whether they exist there as parasites or as inquilines has not been determined. Species of Mutilla have also been bred from nests of other digger-wasps, and from those of certain true wasps.

Family SCOLIIDÆ (Sco-li'i-dæ).

The Scoliids (*Sco'li-ids*).

The Scoliids are quite closely related to the preceding family but differ in their general appearance, resembling wasps rather than ants. In their habits they do not exhibit as much intelligence as do most digger-wasps, for although they make burrows in the earth, it is said that they do not have the power of building nests and transporting prey to them for their carnivorous larvæ. Instead of this, they dig in the ground in order to find larvæ that have buried themselves to undergo their transformations; and lay their eggs upon such larvæ. These insects occur in sunny, hot, and sandy places; more than forty American species are known.

One of our most common species is *Tiphia inornata* (Tiph'i-a in-or-na'ta); this is a shining black species, and measures three fifths of an inch in length (Fig. 770). It is parasitic upon white grubs, the larvæ of May-beetles. *Elis quadrinotata* (E'lis quad-ri-no-ta'ta) is a magnificent species common in the South. It is black, with four yellow spots on the abdomen, and measures nearly or quite one and one fourth inches in length.

FIG. 770.

Family SAPYGIDÆ (Sa-pyg'i-dæ).

The Sapygids (*Sa-py'gids*).

This is a small family including only two North American genera, and but little more than twenty species. These insects are of moderate size, with short legs, and are usually black, spotted or banded with yellow, rarely entirely black. So far as their habits are known, they are inquilines in the nests of solitary wasps and solitary bees.

Family POMPILIDÆ (Pom-pil'i-dæ).

The Spider-wasps.

The spider-wasps are so called because they provision their nests with spiders. They are slender in form, with long legs (Fig. 771), and are usually black with dusky reddish or black wings; sometimes they are variegated with red or orange. The peduncle is short, so that the abdomen is very closely united to the thorax. Many of the species are of medium size, but some are very large. In fact, the largest of all known Hymenoptera belong to this family.

FIG. 771.—*Pompilus.*

One of the giants of the family is the well-known Tarantula-hawk, *Pepsis formosa* (Pep'sis for-mo'sa), of the Southwest, which stores its burrows with Tarantulas. Many a hard-fought battle does this digger-wasp have with these enormous spiders; and sometimes it is conquered and ignominiously eaten.

Most of the Pompilidæ dig burrows in the ground; but some species of *Agenia* (A-ge'ni-a) make cells of mud attached to the lower surface of stones or in the chinks of walls; and the members of the genus *Ceropales* (Ce-rop'a-les) are inquilines in the nests of other digger-wasps.

About one hundred and twenty species belonging to this family are known in our fauna.

Family SPHECIDÆ (Sphec'i-dæ).

The Sphecids (Sphe'cids) or the Thread-waisted Wasps.

These are the most commonly observed of all our digger-wasps as certain species build their mud nests in the attics of our houses; and, too, the peculiar shape of the body makes them very conspicuous. The Sphecidæ differ from the preceding families of digger-wasps in that the pro-

thorax is not prolonged backward on each side to the base of the fore wing. But the most striking characteristic is that the first segment of the abdomen is generally narrowed into a long, smooth, round petiole (Fig. 772), which suggests the popular name given above. The venation of the wings of one of our more common species is represented by Fig. 773. The fore wing

FIG. 772.—*Pelopœus cementarius.*

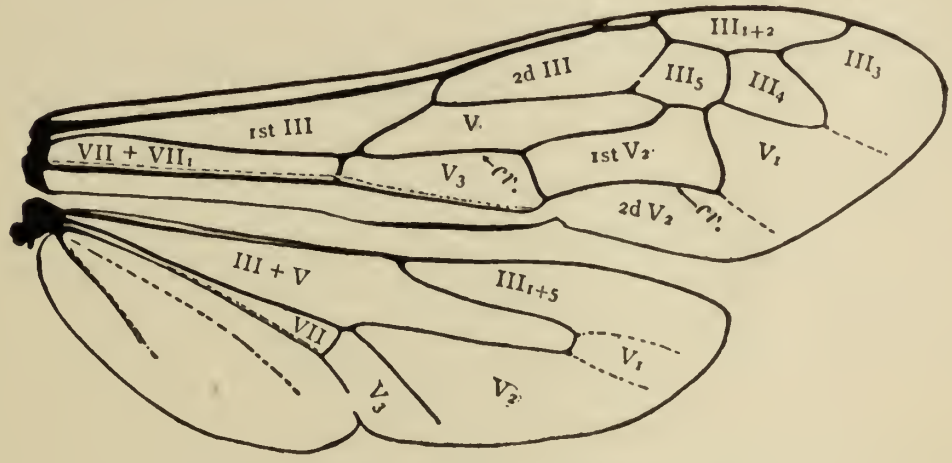

FIG. 773.—Wings of *Pelopœus cementarius.*

in this family has three closed submarginal cells (2d III, III_5, and III_4), and the last branch of vein V (vein V_3) arises beyond the end of the 2d cell III. Most of the species burrow into sand-banks, and provision their cells with caterpillars and spiders. But those best known to us are the mud-daubers. These belong to the genus *Pelopœus* (Pel-o-pœ'us). They make nests of mud attached to the lower surface of flat stones or to the ceilings of buildings. These nests usually have the form of several tubes an inch or so long placed side by side, and are provisioned with spiders.

The mud-daubers may be seen in damp places collecting mud for their nests, or exploring buildings in search of a place to build. They have a curious habit of jerking their wings frequently in a nervous manner.

About seventy species of this family occur in this country.

Family LARRIDÆ (Lar'ri-dæ).

The Larrids (Lar'rids).

FIG. 774.—*Larra terminata.*

This family is composed of insects of moderate size and rather slender form. The abdomen is ovoid-conical in outline (Fig. 774); there is a single spine at the apex of the middle tibiæ; the fore wings have an appendiculate cell (Fig. 775, *ap*); and the mandibles are usually notched on the exterior margin.

These insects burrow in sandy places, and provision their

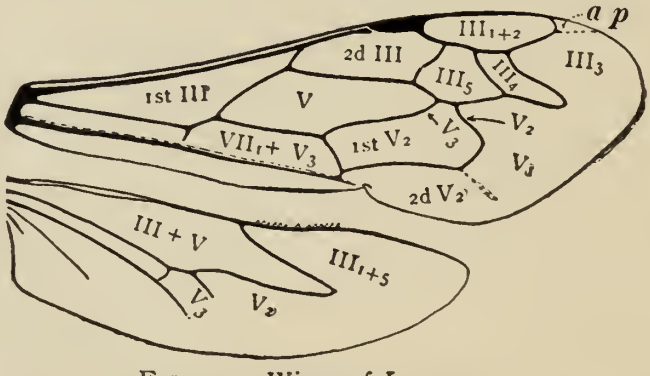

FIG. 775.—Wings of *Larra*.

nests chiefly with orthopterous insects. Some species frequent milk-weed (*Asclepias*) blossoms, but are very difficult to capture.

More than fifty species have been found in the United States and Canada; most of them occur in the Southwest.

Family BEMBECIDÆ (Bem-bec'i-dæ).

The Bembecids (Bem'be-cids.)

The members of this family are most easily distinguished from the closely-related forms by the shape of the upper lip, which distinctly projects. In some genera it not only projects, but is prolonged so as to appear like a beak.

Great variations in size occur within the family, The majority of our species are of moderate size; but some of

them are among the larger insects of the order. The family includes two quite distinct subfamilies.

To the *Bembecinæ* (Bem-be-ci′næ) belong the smaller forms, which are usually black with greenish or greenish-yellow bands. With these the labrum is longer than the clypeus, forming a triangular beak (Fig. 776). They burrow in sand, and provision their nests with flies.

FIG. 776.— Face of *Bembex*. *l*, labrum.

To the *Stizinæ* (Sti-zi′næ) belong the giants of the family. With these the labrum is shorter than the clypeus (Fig. 777). Our best-known representative is the Cicada-killer, *Sphecius speciosus* (Sphe′ci-us spe-ci-o′sus). It is a formidable insect, measuring one and one fourth inches in length. It is black, sometimes of a rusty color, and has the abdomen banded with yellow (Fig. 778). It digs burrows in the earth,

FIG. 777.— Face of *Sphecius*. *l*, labrum.

FIG. 778.— *Sphecius speciosus*.

two feet or more in depth, and provisions each with a Cicada. Many a Cicada-song has been suddenly silenced because the singer was pounced upon and carried off alive but helpless to be buried in the den of this fierce, handsome insect of prey.

Family NYSSONIDÆ (Nys-son'i-dæ).

The Nyssonids (*Nys-so'nids*).

These digger-wasps are of medium size. Some of them are remarkable for their close resemblance in form and markings to true wasps of the family Eumenidæ ; but they do not plait their wings like the true wasps. Little is recorded regarding their habits; some species provision their nests with nymphs of leaf-hoppers, others with spittle-insects (Homoptera). It is said that the species of the typical genus *Nysson* (Nys'son) have the habit of feigning death and dropping to the ground when alarmed.

We have about fifty species of this family in our fauna.

Family PHILANTHIDÆ (Phi-lan'thi-dæ).

The Philanthids (*Phi-lan'thids*).

These digger-wasps are easily recognized by the characters given in the table above. Figure 779 represents the wing

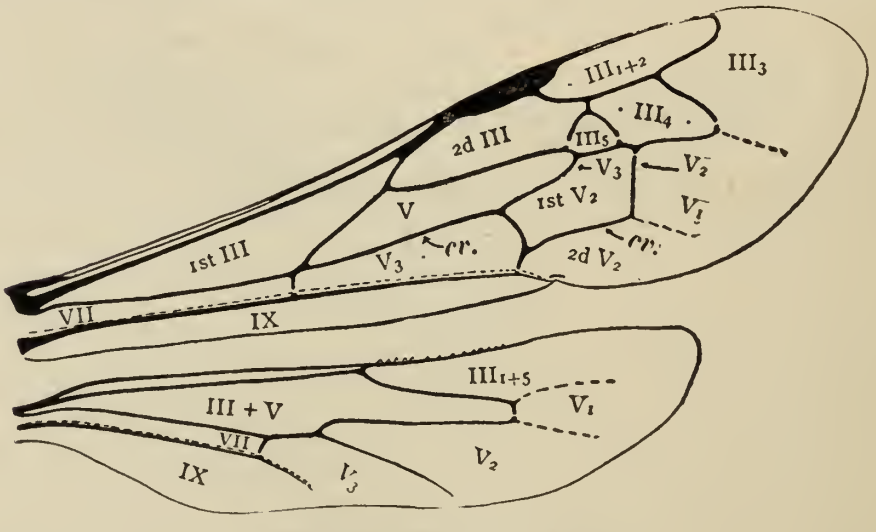

FIG. 779.— Wings of *Cerceris*.

of *Cerceris* (Cer-ce'ris) and shows the typical venation. The males are peculiar in having a fringe of hairs resembling a mustache on the free edge of the clypeus on each side.

The Philanthids burrow in the earth. Some provision their nests with bees; others with beetles. The family contains about seventy-five North American species.

Family MIMESIDÆ (Mi-mes'i-dæ).

The Mimesids (*Mi-me'sids*).

The Mimesids are small digger-wasps in which the base of the abdomen is slender, forming a petiole much like that of the Sphecids, but differing in being flattened and usually furrowed above (Fig. 780). These digger-wasps are much smaller than the true thread-waisted wasps. Less than a score of North American species are known. They make their burrows in the pith of brambles, and provision them with Aphids or Psyllids.

FIG. 780.— A Mimesid.

Family PEMPHREDONIDÆ (Pem-phre-don'i-dæ).

The Pemphredonids (*Pem-phre-do'nids*).

Most of the species of this family are slender insects, of small size and shining black color. They can be distinguished from the closely-related families by the presence of two, and only two, closed submarginal cells (Fig. 781, 2d III + III_5 and III_4). It is a small family, including scarcely a dozen North American species.

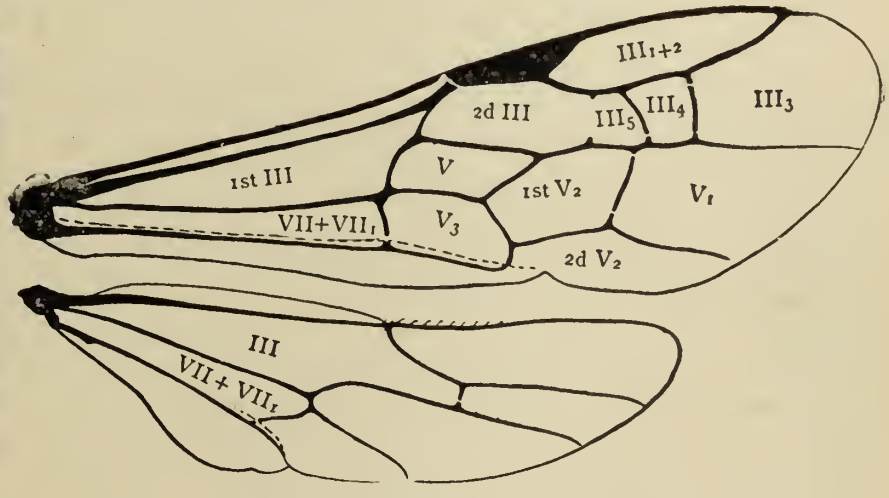

FIG. 781.— Wings of a Pephredonid.

FIG. 782.

The Pemphredonids usually burrow in the pith of dry branches and provision their burrows with plant-lice.

A very common species in the East is *Stigmus fraternus* (Stig'mus fra-ter'nus). This insect measures one fifth of an inch or less in length, and makes very tortuous burrows in the pith of sumach (Fig. 782). Other common members of the family are larger.

Family CRABRONIDÆ (Cra-bron'i-dæ).

The Crabronids (*Cra'bro-nids*).

The Crabronids can be distinguished from all other digger-

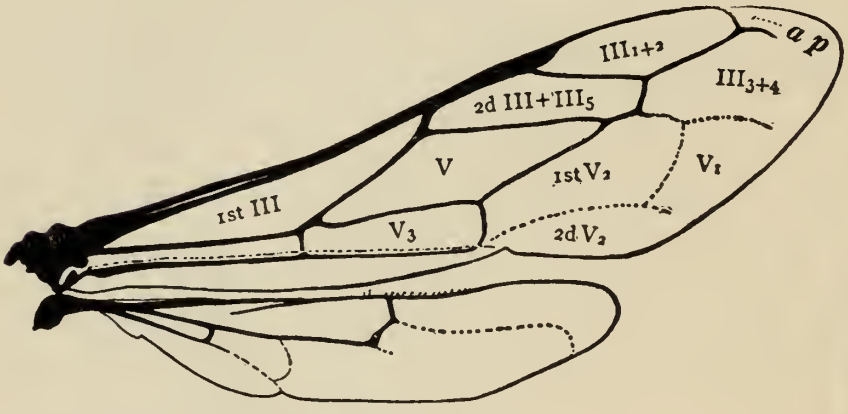

FIG. 783.—Wings of *Crabo singularis*.

wasps that occur in this country by the venation of the fore wings, in which there is only one closed submarginal cell (Fig. 783, 2d III + III$_5$). The head is generally large, and nearly square when viewed from above, and sometimes broader than the thorax (Fig. 784).

FIG. 784.—*Crabro.*

The different members of this family vary greatly in their nesting habits. Some mine in the pith of such plants as sumach and elder; some bore in more solid wood; some dig burrows in the ground; and others make use of any suitable hole they can find, often the deserted burrow of some other insect. These insects usually provision their nests with flies; but we have found spiders in the nests of some.

FIG. 785.—Nest of *Trypoxylon frigidum.*

We have found the nests of *Trypoxylon frigidum* (Try-pox'y-lon frig'i-dum) very common in branches of sumach (Fig. 785), more common perhaps than those of any other insect except the little carpenter-bee, *Ceratina*. The cells of the nest of *Trypoxylon* are separated by partitions of mud, and the pupa when full grown makes a very slender cocoon, with the upper end rounded and sometimes slightly swollen, and the lower end blunt and of denser texture than the remainder of the cocoon. The adult insect is very slender and lacks the yellow bands on the abdomen, possessed by most members of this family.

Superfamily VESPINA (Ves-pi'na).

The True Wasps.

All members of this superfamily are winged, and when at rest fold their wings lengthwise like a fan. In this last respect they differ from all other Hymenoptera except a single genus of Chalcis-flies, *Leucospis* (Leu-cos'pis). The prothorax is prolonged backwards on each side to the base of the front wing ; the eyes are kidney-shaped ; and the legs are not formed for burrowing, being free from spines and bristles.

Three families are included in this superfamily ; these can be separated by the following table :—

A. Antennæ clavate or knobbed at tip. p. 657.....MASARIDÆ.
AA. Antennæ filiform or nearly so.
  B. Tibiæ of the middle legs with a single terminal spur; tarsal claws armed with a tooth. p. 658.....EUMENIDÆ.
  BB. Tibiæ of the middle legs with two terminal spurs ; tarsal claws simple. p. 660.....VESPIDÆ.

Family MASARIDÆ (Ma-sar'i-dæ).

The Guest-wasps.

This is a small family of which only seven species are known to occur in the United States. These are found in Texas and the far West. As yet nothing is known regarding

the habits of our species. But as an European species has been bred from the nest of a digger-wasp, it is inferred that the members of this family are inquilines.

Family EUMENIDÆ (Eu-men'i-dæ).

The Solitary Wasps.

All of the variations in habits found among digger-wasps occur in this family. Some are miners, digging tunnels in the earth ; some are carpenters, cutting tubular nests in wood and then showing a mason's skill by partitioning their tunnels off into cells with mud. While others are masons pure and simple, and build oval or globular mud-nests which they fasten to twigs of trees; such nests often contain many cells. All of these wasps are predaceous, provisioning their nests with insects.

One species, *Eumenes fraternus* (Eu'me-nes fra-ter'-nus), makes a neat little nest, which appears like a miniature

FIG. 786.—*Eumenes fraternus* and its nest.

water-jug (Fig. 786). These Mason-wasps have a very characteristic form. The peduncle of the abdomen is shaped like a bell with a long handle. The segment of the abdomen next to the peduncle is large and globe-shaped. The segments behind this taper off into a point, giving the whole

abdomen the shape of an old-fashioned earring. This species provisions its nest with caterpillars, and frequently with the canker-worm.

The greater number of our solitary wasps belong to the genus *Odynerus* (Od-y-ne'rus). In this genus the abdomen is joined to the thorax by a very short peduncle. The shape of the body and frequently the coloration resemble those of the social wasps known as yellow-jackets, although usually the body is more slender and smaller. The common species are quite neighborly; and owing to this resemblance to the yellow-jackets, they inspire us with a fear that is out of all proportion to their will or ability to inflict pain.

The wasps of this genus exhibit a great variation in habits. Many species burrow in the stems of pithy plants, making a series of cells separated by mud partitions; other species will avail themselves of any convenient cavity in which to make their nests, frequently utilizing the deserted nests of mud-daubers. In this case a single cell of a mud-dauber is divided by a transverse partition making two cells for the smaller

FIG. 787.—*Monobia quadridens.*

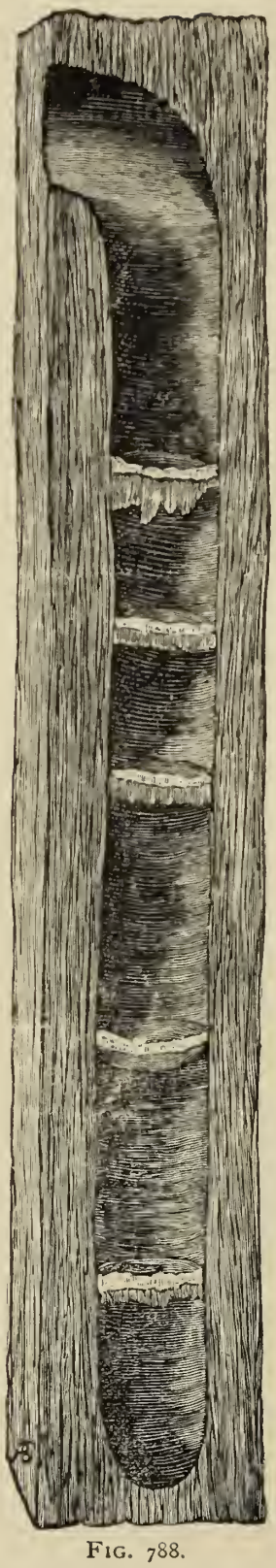

FIG. 788.

Odynerus. One year these wasps plastered up many of the

keyholes in our house, including those in the bureaus; thus constructing for us locks that required a good deal of time and industry on our part to open. Some species of *Odynerus* are masons constructing nests entirely of mud. One of our species makes a nest about the size of a hen's egg. This is composed of hard clay, fastened to a twig of a bush, and contains many cells.

Probably the most skilful of architects among our solitary wasps is *Monobia quadridens* (Mo-no'bi-a quad'ri-dens), a species common in most of the states east of the Mississippi (Fig. 787). This insect bores a tunnel in solid wood. Figure 788 represents a nest in our collection which was made in a board in the side of a barn. The partitions are made of mud. Each cell contained a pupa when the nest was opened; so we do not know with what the nest was provisioned.

Family VESPIDÆ (Ves'pi-dæ).

The Social Wasps.

Here again, as with the ants, we find colonies consisting of three forms of individuals, males, females, and workers. The colonies exist for only one season; the males and workers die in the autumn; the females hibernate and each starts a new colony in the spring. In the early part of the season only workers are produced; later the males and females appear. The three forms are similar in coloring. They are all winged, and the queens and workers are provided with venomous stings. The queens are larger than the workers, and the males have seven segments in the abdomen, while the others have only six. The male wasps do not sting, but they bear such a close resemblance to the belligerent, well-armed workers that this interesting bit of knowledge is entirely useless. When we see a hornet our interest in its sex hardly leads us to test it to see whether it will sting, or to examine it closely to ascertain if it has seven abdominal segments. If male wasps wish to get any credit for their amiability,

they would do well to change their spots, so that they can be distinguished at a distance.

Social wasps build their nests in the ground, or attach them to bushes and trees, or to the roofs or eaves of buildings. The nests are made of paper composed of bits of wood converted into a paste by the action of the jaws. Probably these insects add a fluid excreted by the mouth to the fibres of wood in order to make the paste, but of this we have no definite knowledge.

The species that build their nests above ground make a grayish paper composed of fibres of weather-worn but not decayed wood. This material is collected from stumps of trees, fences, and the sides of unpainted buildings. This paper is comparatively strong ; so that, in those cases where the combs are enclosed in an envelope, the envelope is composed of sheets of paper of considerable size, a single sheet often completely enveloping a nest.

But most of the species that build their nests in the ground make their paper out of partially-decayed wood. This paper is brownish in color and is very fragile; it would not be suitable, therefore, for use in nests built in exposed places. Even when the nest is built in a hole in the ground, the use of this fragile material necessitates a different style of architecture. The enveloping layers of the nest, instead of being composed of sheets of considerable size, are made up of small, overlapping, shell-like portions, each firmly joined by its edges to the underlying parts.

The social wasps are predaceous; and they feed their young upon insects which they have masticated. These wasps are also fond of sweets of flowers, the juices of fruits, and of honey-dew. They collect the honey-dew from leaves in the vicinity of Aphids without, so far as we know, rendering the Aphids any service in return.

Except in California, only two genera of social wasps occur in the United States. These are *Polistes* (Po-lis'tes) and *Vespa* (Ves'pa). Each of these genera is represented

by a number of species. In California there is a single representative of a third genus, *Polybia* (Po-lyb'i-a). This genus differs from the other two genera, in having the first abdominal segment long and slender, forming a peduncle. Our species is *Polybia flavitarsis* (P. flav-i-tar'sis).

Polistes.—In this genus the abdomen is long and spindle-shaped (Fig. 789). The species are black, ringed with yellow, or are brownish. Their nests consist each of a single comb, suspended by a peduncle, and are not enclosed in an envelope (Fig. 790). In the fall these fellows are quite as familiar as the mud-daubers, which they resemble in color. However, they are easily distinguished from these, as the abdomen is not on such an absurdly long peduncle,

FIG. 789.—*Polistes.*

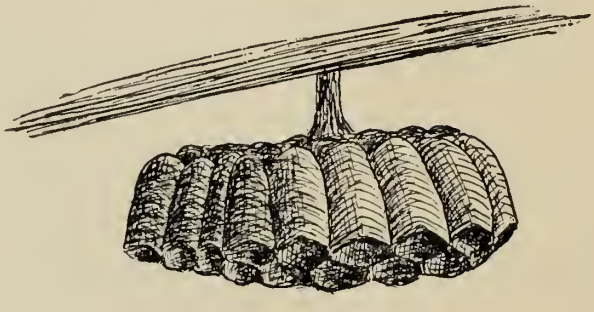

FIG. 790 — Nest of *Polistes.*

and their wings fold like fans. They come into our houses searching for warm crevices in which to pass the winter.

Vespa.—To this genus belong the wasps commonly known as yellow-jackets and as hornets. With these insects the body is comparatively short and rather stout (Fig. 791); the abdomen is attached to the thorax by a very short peduncle; the color is black, spotted and banded with yellow or yellowish white. The species of this genus enclose the combs of their nest with a spherical paper envelope (Fig. 792). Any person

FIG. 791.—*Vespa.*

who has no respect for the rights of yellow-jackets has before him a lesson which he will have no difficulty in learning, if he takes the pains to disturb one of the oval, gray paper nests commonly found hanging from the eaves of buildings. The yellow and black mass of seething and buzzing vengeance that can pour out of the hole in the bottom of one of these nests seems almost as wonderful as the miraculous multiplication of the loaves and fishes. And these insects do not threaten more than they can perform: their painful

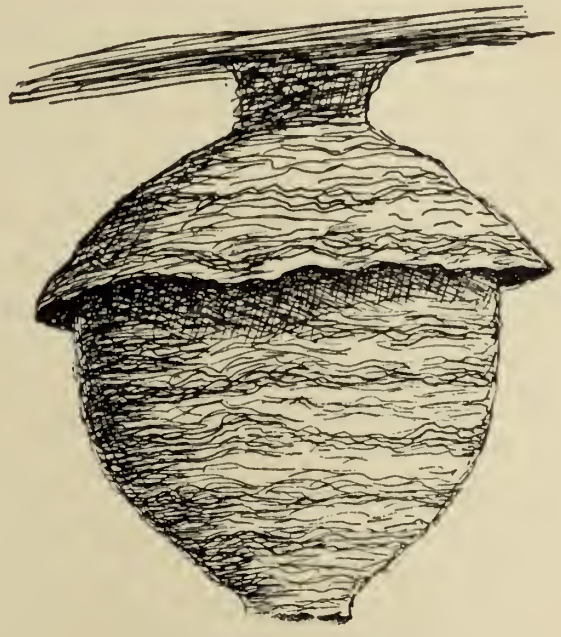

FIG. 792.—Nest of *Vespa*.

stings are so well known, that neither man nor beast trespasses willingly on their domains. Their nest is a real palace of papier-maché. It consists of several horizontal combs suspended one above the other, with commodious galleries between, and all enveloped by an elaborate covering made of many folds of water-proof paper. The yellow-jackets are clever and original artisans. Once we chanced, most inadvertently, to lift a board and thereby tear off the whole roof of a nest; naturally we beat a hasty retreat. On returning to the spot a few days later we found the nest neatly and thoroughly covered with a sloping water-proof roofing of

paper, although this was probably the first time in these yellow-jackets' history that such a problem in architecture had occurred. When these wasps wish to enlarge their nest they tear away the inner layers of the envelope, add to the sides of the comb, and put on new layers on the outside of the envelope. The yellow-jackets that build their habitation in the ground excavate a hole which is enlarged gradually as the colony grows.

Superfamily APINA (A-pi'na).

The Bees.

The bees can be distinguished from all other Hymenoptera by the form of the basal segment of the hind tarsi (Fig. 737, *c*). This segment is more or less dilated, flattened, and generally hairy, and bears an apparatus for collecting and carrying pollen. In the inquiline bees, however, this segment is narrower, and is not furnished with organs for collecting and carrying pollen.

Sometimes, in the case of those species that most closely approach the wasps in structure, it is difficult to distinguish bees by a study of the tarsi alone. But there is a microscopic character which is said to be reliable even in these cases. It is said that the bees differ from all other Hymenoptera in the form of the hairs clothing the body, which, at least those of the thorax, are branched or plumose (Fig. 793), while in all other members of the order they are simple.

FIG. 793.

The different species of bees exhibit great variations in habits: some are solitary, each female providing a nest for her young; some are inquilines, laying their eggs in the nests of other bees; and a few are social, of which the honey-bee is the most familiar example. But in all the nest is provisioned with pollen or honey, or both. In this respect the bees differ

distinctly from the wasps and the digger-wasps, which provision their nests with other insects or with spiders.

The superfamily Apina includes two families: the Andrenidæ or short-tongued bees, and the Apidæ or long-tongued bees. These can be separated as follows:—

A. Bees with the terminal portion of the lower lip, the glossa, flattened and shorter than the mentum; and with the basal segments of the labial palpi not unlike the following segments. p. 665. ANDRENIDÆ.

AA. Bees with the glossa slender, not flattened, and longer than the mentum; and with the basal segments of the labial palpi elongate. p. 666.... .....APIDÆ.

Family ANDRENIDÆ (An-dren'i-dæ).

The Short-tongued Bees.

The family Andrenidæ includes several genera of bees which agree in having the glossa shorter than the mentum, and flattened (Fig. 794). In some genera the glossa is spear-shaped, in others it is heart-shaped.

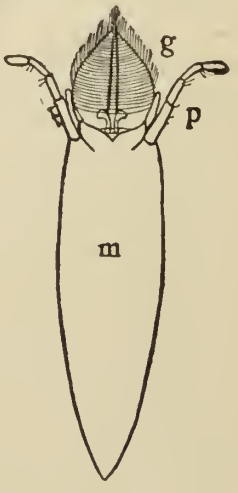

FIG. 794.—Labium of *Sphecodes*. *m*, mentum; *p*, palpus; *g*, glassa

The different genera of this family vary greatly in habits, but none of the species are social. Among the more common short-tongued bees are some that make their nests in the ground, and on this account are termed mining-bees. It should be remembered, however, that some of the Apidæ are also mining-bees, and that not all of the Andrenidæ are miners.

The nest of a mining-bee usually consists of a tunnel, more or less branched, each branch leading to a single cell. The walls of these cells are glazed, appearing like the surface of earthenware. In each cell there is stored a quantity of pollen and nectar-paste, an egg is laid with this food, and the cell is then closed up.

Among the larger of our common mining-bees are those

of the genus *Andrena* (An-dre'na). Some of these nearly or quite equal in size the workers of the honey-bee. They build their nests in grassy fields, sinking a perpendicular shaft with branches leading sidewise to the cells. The main shaft sometimes extends to a depth of more than one foot. These bees, though strictly solitary, each female building her own nest, frequently build their nests near together, forming large villages. Sometimes a village, or we might say a city, of this kind, covering only one square rod of ground, will include several thousand nests. While writing this account we have received from a correspondent a description of a collection of nests of this kind which was fifteen feet in diameter, and in the destruction of which about two thousand bees were killed—a terrible slaughter of innocent creatures!

The smallest mining-bees, in fact the smallest of all our bees, belong to the genus *Halictus* (Ha-lic'tus). These measure from one one-tenth to three one-tenths of an inch in length. They usually burrow in the sides of cliffs, and especially in sand-banks, which often look as if they had been used as targets for practice with a shot-gun, so thickly are they studded with burrows of these bees. A remarkable feature in the habits of the bees of this genus is that several females unite in making a burrow into a bank, after which each female makes passages extending sidewise from this main burrow or public corridor to her own cells. While *Andrena* builds villages composed of individual homes, *Halictus* makes cities composed of apartment-houses.

Family APIDÆ (A'pi-dæ).

The Long-tongued Bees.

In the Apidæ we find that the lower lip has been highly specialized for the procuring of nectar from deep flowers. Here the glossa is slender and greatly elongate, being longer

than the mentum (Fig. 795); the basal segments of the labial palpi are also elongate.

A remarkable difference in habits exists among the different species of this family: some are solitary; others are inquilines; and a few are social. Among the solitary species we find an even greater variation in the form of the nest than we found among the solitary wasps or among the digger-wasps. Some of these bees are miners, digging tunnels in the ground; some are masons, making their nests out of mortar-like mud; some are carpenters, boring tunnels in the pith of plants or in solid wood; and some are leaf-cutters, lining their nests with pieces of leaves or of petals of flowers. We have space to describe the habits of only a few of these.

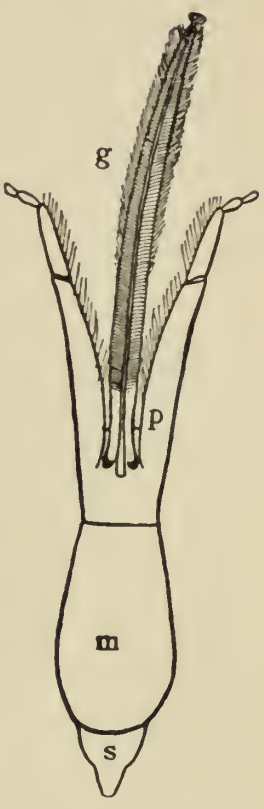

FIG. 795.—Labium of the Honey-bee: *s*, submentum; *m*, mentum; *p*, palpus; *g*, glossa.

I. THE SOLITARY LONG-TONGUED BEES.

The Leaf-cutter Bees, *Megachile* (Meg-a-chi'le).—The bees of the genus Megachile have the curious habit of making cells for their young out of neatly-cut pieces of leaves. These cells are packed away in such secure places that one does not often find them; but it is a very easy thing to find fragments of leaves from which the pieces have been cut by bees. The leaves of various plants are used for this purpose, but rose-leaves are used more frequently than any other kind. In Figure 796 there are represented one of these bees, its nest, and a spray of rose-leaves from which pieces have been cut by the bee.

The species represented here, *Megachile acuta* (M. a-cu'ta), is a carpenter as well as a leaf-cutter. It first makes a tunnel in wood, often selecting that which is partially decayed; then it proceeds to build a thimble-shaped tube at the bot-

tom of this tunnel. For this purpose it cuts from the leaves oblong pieces, each of which forms a part of a side and the bottom of the thimble-shaped tube. Two such pieces had been cut from the lower leaf on the left side of the spray figured here. When the thimble-shaped tube is completed, the bee partially fills it with a paste of pollen and nectar, and then places an egg upon the supply of food. She then cuts several circular pieces of leaves, the diameter

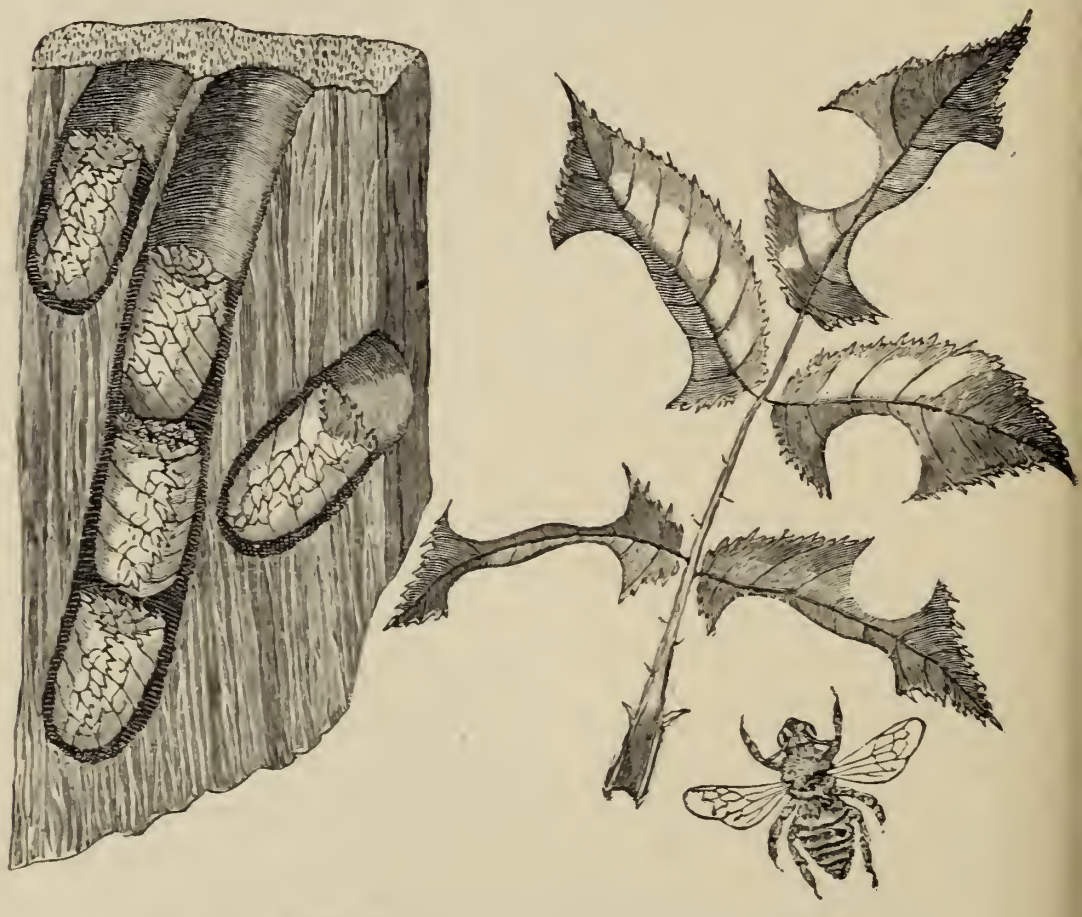

FIG. 796.—A leaf-cutter bee, nest, and rose-leaves cut by the bee.

of which is a little greater than the diameter of the tube, and forces them into the open end of it, thus making a tightly-fitting plug ; three of these circular pieces had been cut from the spray figured. Usually several cells of this kind are placed end to end in a burrow ; and sometimes many bees will build their nests near together in the same piece of wood.

The leaf-cutter bees do not always bore tunnels in which

to place their cells. We have found these cells in a crack between shingles on a roof, in the cavity of a large branch of sumach, beneath stones lying on the ground, and in Florida in the tubular leaves of a pitcher-plant.

Some species of bees make nests similar to those of the leaf-cutter bees, except that the cells are formed of pieces of petals of flowers. The petals of Pelargonium are often used for this purpose.

The small Carpenter-bee, *Ceratina dupla* (Ce-rat'i-na du'pla).—The nests of this bee are built in dead twigs of sumach and in the hollows of brambles and other plants. They are more common than those of any other of our solitary bees that build in these situations. This is a dainty little bee, about a quarter of an inch long, and of a metallic blue color. She always selects a twig with a soft pith which she excavates with her mandibles, and so makes a long tunnel. Then she gathers pollen and puts it in the bottom of the nest, lays an egg on it, and then makes a partition out of pith-chips, which serves as a roof to this cell and a floor to the one above it. This process she repeats until the tunnel is nearly full, then she rests in the space above the last cell, and waits for her children to grow up. The lower one hatches first; and, after it has attained its growth, it tears down the partition above it, and then waits patiently for the one above to do the same. Finally, after the last one in the top cell has matured, the mother leads forth her full-fledged family in a flight into the sunshine. This is the only case known to the writer where a solitary bee watches her nest till her young mature. After the last of the brood has emerged from its cell, the substance of which the partitions were made, and which has been forced to the bottom of the nest by the young bees when making their escape, is cleaned out by the family, the old bee and the young ones all working together. Then the nest is used again by one of the bees. We have collected hundreds of these nests, and, by opening different nests at different sea-

sons, have gained an idea of what goes on in a single nest. There are two broods each year. The mature bees of the fall brood winter in the nests.

The Large Carpenter-bee, *Xylocopa virginica* (Xy-loc'o-pa vir-gin'i-ca).—This is a large insect, resembling a bumblebee in size, and somewhat in appearance. But it can be easily distinguished from a bumblebee, as the female has a dense brush of hairs on the hind leg, instead of a basket for carrying pollen. This bee builds its nest in solid wood, and sometimes excavates a tunnel a foot in length. These tunnels are similar to those of the carpenter-wasp, *Monobia quadridens* (Fig. 788); but differ in being provisioned with a paste of pollen and nectar, and in the structure of the partitions. These are made of chips of wood, securely cemented together, and arranged in a closely-wound spiral. This arrangement of the chips is easily seen when the lower side of a partition is examined; but the upper side of a partition, which forms the floor of the cell above it, is made concave and very smooth, so that the arrangement of the chips is not visible.

II. THE GUEST-BEES OR INQUILINES.

Although bees are proverbially industrious, we find many loafers in the family. We do not refer to the lazy males of those species in which the females are hard workers, but to certain species in which both sexes are alike idle, and dependent upon the exertions of other species of bees. These idle species are called guest-bees, or inquilines, because they are reared in the nests of other bees, who act, willingly or unwillingly, as hosts.

The guest-bees are entertained both by solitary bees and by social bees; but each species of guest-bee inhabits the nests of a particular kind of working bee. Thus the nests of certain bees are visited by certain guest-bees, while those of other species are infested by different guests. This habit of sponging their living has had a degrading effect on the guest-bees; for we find that they are not merely idle, but

are actually unable to work; as shown by the fact that the organs for collecting and carrying pollen have been lost through disuse.

The inquiline bees that infest the nests of solitary bees resemble the cuckoo-flies in habits, watching their opportunity to steel into a partially completed nest, and, cuckoo-like, laying an egg there. The larva of the guest-bee hatching first is able to devour the food stored there, and thus starves the rightful occupant of the nest. We have in our collection many nests of solitary bees in which more than half of the cells were inhabited by inquilines.

The relations existing between the solitary bees and their unwelcome guests are easy to understand; but when we study the nests of bumblebees we find that they, too, have guests: but in this case the guests are apparently welcome, although, so far as we have been able to learn, they are of no use to the colony.

The inquilines infesting the nests of bumblebees belong to the genus *Psithyrus* (Psith'y-rus). These bees so closely resemble bumblebees in appearance and structure that it is extremely difficult to determine whether a male is a *Psithyrus* or a *Bombus*; but the females are easily distinguished, for in *Psithyrus* the pollen-basket of the hind legs has been lost through disuse. In *Psithyrus* there are only two forms of individuals, the males and the females, there being no working caste, as with bumblebees.

The female *Psithyrus* lays her eggs in a bumblebee's nest, and when the larvæ hatch they are cared for by the bumblebees as if they belonged in the nest. And even after the guests have reached maturity they come and go in the nest without being disturbed, although they never lend a helping mandible in carrying on the work of the colony. Sometimes these guests very closely resemble their hosts in size and color, but in other cases the *Psithyrus* is marked very differently from the *Bombus* that entertains it. We cannot suppose, therefore, that the guests are mistaken for mem-

bers of the family. Neither is it probable that the bumblebees are unable to drive their guests away. Let any one inclined to this view disturb a bumblebee's nest, and he will probably have an increased appreciation of their powers of defence. These facts have led some naturalists to believe that these aristocratic guests perform some important and necessary duties conducive to the general prosperity of the whole colony, although as yet we have not the slightest hint as to what these duties may be.

III. THE SOCIAL BEES.

The social bees are so called because many individuals work together to build a common home. Here, as with the ants and with the social wasps, we find three forms of individuals—the males or drones, the females or queens, and the workers. The workers are a caste of females that rarely lay eggs, but are especially adapted for performing the labors of the colony.

Our native social bees belong to the genus *Bombus*, and are commonly known as bumblebees. Of these more than fifty species have been described from North America. We have also an introduced, domesticated species, the Honey-bee, which now lives wild in all parts of our country, building its nest in hollow trees and in other situations.

The Bumblebees, *Bombus* (Bom'bus).—The clumsy rover, the bumblebee, is an old friend of us all. As children we caught her off thistle-blossoms and imprisoned her in emptied milkweed pods, and bade her sing for us. We robbed her nest in the hay-field, and tried to believe that the strongly-flavored honey, mixed with dirt, was delicious. And all our lives the sound of her droning has brought to us visions of blue skies, roadsides golden with buttercups, and fields purple with clover-blossoms. And she has deserved all the attention and affection bestowed upon her, because she is usually good-natured and companionable. She is a happy-go-lucky insect, and takes life as it comes

without any of the severe disciplining and exact methods of her cousin, the honey-bee.

With the bumblebees the queens are larger than either the workers or the males, and are the only ones that live through the winter. In early spring we often see one of these great queens flying low, and inspecting our meadows and pastures for a building-place. She chooses some deserted mouse-nest in the meadow, and places within it a ball of pollen, upon which she lays some eggs. As soon as the larvæ hatch they eat into the pollen-mass in all directions, and when full grown make for themselves silken cocoons, and change to pupæ. These cocoons the old bees strengthen with wax, and after the young bees vacate them they are used as storing cells for honey. This explains the irregularity of the bumblebee-comb. The first broods of the season are workers, and relieve the queen of all duties except laying the eggs. Later in the summer males and females appear, and it can be said to the credit of the bumblebee queens that they are not jealous, but allow the young queens to live with them in the nest. In the autumn the colony breaks up, and all of the bees, except the young queens, perish. These crawl away into some protected place and pass the winter. In the spring each queen that has survived the winter founds a new colony, performing, until a brood of workers has been developed, both the duties of queen and of worker.

The Honey-bee, *Apis mellifica* (A′pis mel-lif′i-ca).—Neat rows of hives on a sunny slope, with an orchard on one side and wide-stretching meadows on the other, the busy hum of comers and goers of this city of cities, the odor of honey weighing down every passing breeze—these constitute one of the most home-like possessions of the ideal country-home.

The honey-bee, through its useful products, has been known and cared for by man for centuries. Philosophers have written about it, poets have sung its praises, and nat-

uralists have studied it during past ages, until there is probably no other insect with which man has such an intimate acquaintance. The honey-bee was originally a European species, but has been domesticated the world over. It was introduced into America more than three centuries ago, and escaping swarms have stocked our forests with what we call wild bees, for when free they almost universally build their nests in hollow trees. These insects offer a no less interesting study of communistic society than do ants. There are in each community three forms of individuals—the queen or female, the drones or males, and the workers, which are imperfectly developed females. The worker is our common acquaintance, the dull-black and gold-colored companion of our walks, that we watch with interest as she ransacks the flowers of a garden or a wayside for her booty of nectar or pollen, now bending low a violet or a clover-blossom, now plunging head foremost into a hollyhock or a lily, from which she emerges dusty with the gold of pollen-doors which barred her way to nectar-chambers. We marvel at her industry ; but she is ever driven on with the sense of her responsibilities : for the worker-sisterhood must do all the work of the hive, collect and store the food, manufacture the wax, build the comb, take care of the footless, helpless larvæ, fight the battles for protection, and manage affairs generally.

The drones are larger than the workers, and are reared in larger cells. If honeycombs be examined, some sheets will be seen to be composed of larger cells than those of the more common type. It is in cells of this kind that the eggs are laid which are to develop into males. In shape the drones are broader and blunter than the workers. They are few in numbers, and are only present in the hive during the early summer. After the swarming season is over, these gentlemen of leisure are driven out of the hive by the workers or are killed by them.

The queen is larger than a worker, and has a long,

pointed body. She is developed in a cell which differs greatly from the ordinary hexagonal cell of honeycomb. This cell is large, cylindrical, and extends vertically. In Figure 797 the beginnings of two queen-cells are represented on the lower edge of the comb, and a completed cell extends over the face of the comb near the left side. From the lower end of this cell hangs a lid, which was cut away by the workers to allow the queen to emerge.

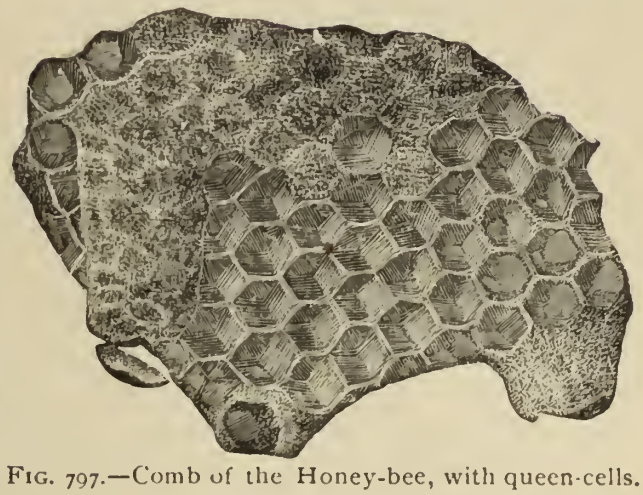

FIG. 797.—Comb of the Honey-bee, with queen-cells.

The larvæ that are to develop into either workers or drones, and which are contained in hexagonal, horizontal cells, are fed with honey and bee-bread. But the occupant of a queen-cell is furnished with very different food—a substance called by bee-keepers royal jelly. This royal jelly is a substance which resembles blanc-mange in color and consistency. It is excreted from the mouth by the workers, and is a very nutritious food.

It has been demonstrated that in the egg state there is no difference between a worker and a queen. When the workers wish to develop a queen they tear down the partitions between three adjacent cells containing eggs that under ordinary conditions would develop into workers. Then they destroy two of the eggs, and build a queen-cell over the third. When the egg hatches they feed the larva with royal jelly, and it develops into a queen.

In early summer several queen-cells are provided in each colony; as soon as a queen is developed from one of these the old queen attempts to destroy her. But the young queen is guarded by the workers, and then the old queen

with a goodly portion of her subjects swarm out, and they go off to start a new colony.

This swarming of the honey-bee is essential to the continued existence of the species; for in social insects it is as necessary that the colonies be multiplied as it is that there should be a reproduction of individuals. Otherwise, as the colonies were destroyed the species would become extinct. With the social wasps and with the bumblebees the old queen and the young ones remain together peacefully in the nest; but at the close of the season the nest is abandoned by all as an unfit place for passing the winter, and in the following spring each young queen founds a new colony. Thus there is a tendency towards a great multiplication of colonies. But with the honey-bee the habit of storing food for winter, and the nature of the habitations of these insects, renders it possible for the colonies to exist indefinitely. And thus if the old and young queens remained together peacefully there would be no multiplication of colonies, and the species would surely die out in time. We see, therefore, that what appears to be merely jealousy on the part of the queen honey-bee is an instinct necessary to the continuance of the species,

The sting of a queen-bee is no ignoble weapon, but it is never used except against a rival queen. When several young queens mature at the same time there is a pitched battle for supremacy, and the last left living on the field becomes the head of the colony. One morning we found the lifeless bodies of fifteen young queens cast forth from a single hive—a monument to the powers of the surviving Amazon in triumphant possession within.

The materials used by bees are wax and propolis, which serve as materials for construction; and honey and bee-bread, used for food.

The comb is made of wax, which is an excretion of the bee. When a colony needs wax, many of the workers gorge themselves with honey, and then hang quietly in a curtain-

like mass, the upper bees clinging to the roof of the hive, and the lower ones to the bees above them. After about twenty-four hours there appears on the lower surface of the abdomen of each bee little plates of wax that are forced out from openings between the ventral abdominal segments called wax-pockets. Other workers attend to this curtain and collect the wax as fast as it appears, and use it at once in constructing comb. As it requires about twenty-one pounds of honey to make one pound of wax, the bees, who are true economists, make this expensive product go as far as possible. The hexagonal cells of the honeycomb afford an ideally compact arrangement, as if the bees were mathematicians and had fully planned to secure the most room in the least space. The cells of the combs are used both for rearing the young and for storing food.

Propolis is a cement used for cementing up crevices, and is made of a resin which the bees collect from the buds of various trees, but especially the poplar.

Honey is made from the nectar of flowers and is taken into the honey stomach of the bee, and there changed into honey, and then regurgitated into the cells of the comb.

Bee-bread is made from the pollen of flowers, which the bees bring in on the plates fringed with hairs on the hind legs.

There is a large literature concerning the intelligence of bees, but those who love to see rather than merely to think about interesting things will find keenest pleasure in intimate associations with these little communists. One soon learns to love them; and the reward of studying them sympathetically is a satisfaction to the mind far beyond the sweetness of honey to the palate.

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